IDRC · CRDI
International Development Research Centre
Centre de recherches pour le développement international

Canada

Connected Learning for STEM (CL4STEM)

GPE KIX
KNOWLEDGE INNOVATION EXCHANGE

Impact Scaling Phase

CL4STEM Bhutan Report | 2026

Transforming Pedagogy with Technology and the Universal Design for Learning Approach in STEAM Education.

BHUTAN | NIGERIA | TANZANIA | INDIA

Samtse College of Education

Ibrahim Badamasi Babangida University, Lapai

The Open University of Tanzania, Chuo Kikuu Huria cha Tanzania, Since 1992, Quality Education for All

TISS, Re-imagining Futures

Preface

The report presented here is an outcome of the Impact Scaling Phase of the *Connected Learning for Teacher Capacity Building in Science, Technology, Engineering, and Mathematics* (CL4STEM) project that was implemented in Bhutan from July 15, 2025 to January 15, 2026. The aim of this phase was to strengthen the professional capacity of Bhutanese secondary STEM and Art and Humanities teachers in implementing inclusive technology enhanced learner-centred teaching using Universal Design for Learning (UDL) principles. The CL4STEM project was funded by the International Development Research Center (IDRC) under the Global Partnership for Education Knowledge and Innovation Exchange (GPE-KIX) programme. 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 designed need-based Open Educational Resources (OER) modules to support teachers' professional development (PD). This time Bhutan included teachers from Arts and Humanities also along with STEM teachers in applying UDL and education technologies for designing flexible learning environments to accommodate learner variability.

An OER module focused on UDL and educational technology titled, *Transforming Pedagogy with Technology and the Universal Design for Learning Approach in STEAM Education* was hosted on the Moodle Learning Management System (LMS). The PD design was practice based and it started with a one day in-person orientation workshop, followed by a six-week time for completing the module embedded activities and implementing the acquired knowledge and skills. Teachers were also required to submit one lesson plan and a reflection report demonstrating evidence of applying UDL principles and relevant educational technology. To study the impact of the OER, teachers were also administered pre-post survey questionnaires and interviewed six teachers. This report documents findings from data collected through surveys and interviews.

The knowledge and insights gained from this project will be disseminated to relevant educators, researchers, and key stakeholders including the Ministry of Education and Skills Development (MoESD).

Furthermore, wherever possible the findings will be presented as a policy agenda for making evidence-based decisions and promoting inclusive innovative practices in STEAM education.

© SCE -2026

Citation: Impact Scaling Phase. CL4STEM Bhutan (2026).

Authors: Dr. Kinzang Dorji, Dr. Reeta Rai, Dr. Karma Utha & Mr. Tandin Penjor

Except where otherwise noted, this content is licensed under a Creative Commons Attribution 4.0 International license.

Report is available for download at https://www.connectedlearningforstem.org/

Any questions, suggestions, or queries may be sent to us at: info@connectedlearningforstem.org

Disclaimers and Acknowledgement

This work is supported by the Global Partnership for Education Knowledge and Innovation Exchange (GPE KIX), a joint endeavour with the International Development Research Centre (IDRC), Canada. The views expressed herein do not necessarily represent those of IDRC or its Board of Governors.

IDRC · CRDI
International Development Research Centre
Centre de recherches pour le développement international

Canada

BHUTAN | NIGERIA | TANZANIA | INDIA

GPE KIX
KNOWLEDGE INNOVATION EXCHANGE

Project Team

Governance Team

Ibrahim Babangida Badamasi University, Lapai (IBBUL), Nigeria

Tajordeen Mustapha, Current Principal Investigator
Abdullahi Abubakar Kawu, Nodal Officer

Open University of Tanzania (OUT), Tanzania
Edephonce Nfuka, Lead Investigator, Tanzania

Samtse College of Education (SCE), Bhutan
Sonam Rinchen, Lead Investigator, Bhutan
Reeta Rai, Country Coordinator, Bhutan

Tata Institute of Social Sciences (TISS), India

Padma Sarangapani, Principal Technical Consultant Vikas Maniar, Lead Technical Consultant.

Steve Nwokeocha, Advisor

Project Team, SCE, Bhutan

Research: Kinzang Dorji (Lead), Reeta Rai, Karma Utha, Sapna Thapa, Chenga Dorji

ICT Subject Group: Sapna Thapa (Lead), Chenga Dorji, Karma Utha, Kinley, Reeta Rai, Kinzang Dorji

Nodal Officer: Reeta Rai
Financial Officers: Tshering Wangmo and Peyano Uraon

Technical Support Team: Chenga Dorji, Sapna Thapa, Narayan Rasaily.

Research Tool Developers:

Kinzang Dorji, Reeta Rai, Kinley, Chenga Dorji & Sapna Thapa.

Acknowledgement

We extend our heartfelt gratitude to the Director of the Department of School Education and District Education Officer, Ministry of Education and Skills Development (MoESD) for approving our proposal to implement the Impact Scaling phase of CL4STEM project at Norbugang Central School, Samtse Dzongkhag. We also sincerely thank the School Principal and Vice Principal for their leadership, cooperation, and necessary support that made the planning and implementation of the PD successful. We are also deeply grateful to the teachers for their willingness to undertake this PD opportunity, active participation and dedication which made this initiative a huge success. We also extend our sincere thanks to the President, Samtse College of Education for the strategic direction and encouragement provided during the implementation of the project. Finally, we acknowledge the invaluable contribution of the Bhutan CL4STEM project team, whose dedication and hardworking spirit ensured the successful execution of the project. This achievement is truly a result of collective commitment and collaboration.

The Bhutan team also acknowledges the contributions and expertise of Professor Tajordeen Mustapha, Professor Padma Sarangapani, Professor Steve Nwokeocha, Dr. Vikas Maniar, Dr. Rinchen Dorji, and Dr. Abdullahi Abubakar Kawu. Their invaluable insights, suggestions, and guidance significantly improved different stages of our project, contributing to its successful completion. We are deeply thankful to the Global Partnership for Education Knowledge and Innovation Exchange (GPE-KIX) for their guidance and contributions to knowledge exchange and dissemination, capacity building, networking, and scaling the innovation, and to the International Development Research Center (IDRC) for funding this consortium project. We would like to express our sincere thanks to the Vice Chancellor of the Royal University of Bhutan for supporting the initiatives of Samtse College of Education aimed at improving the quality of STEAM education in Bhutanese secondary schools.

Abstract

The Impact Scaling CL4STEM project aimed to strengthen Bhutanese secondary Science, Technology, Engineering, Arts, and Mathematics (STEAM) teachers' capacity to implement inclusive, learner-centred instruction using information and communication technology (ICT)-enabled, Universal Design for Learning (UDL)-aligned Open Educational Resources (OERs). A mixed-methods design was employed, combining quantitative assessments of teachers' knowledge, attitudes, and practices (KAP) with qualitative interviews exploring classroom integration and instructional decision-making. Quantitative results demonstrated consistent improvements in KAP scores, particularly in knowledge and self-reported practices, while qualitative findings highlighted more deliberate lesson planning, diverse modes of content representation, enhanced student engagement, and equitable access strategies. Teachers reported increased confidence in using ICT tools, including Canva, GeoGebra, simulations, and AI-assisted resources, to support inclusive teaching and reduce learning barriers. The convergence of quantitative and qualitative evidence suggests that a practice-based, ICT-supported professional development model can effectively enhance teacher readiness and pedagogical flexibility, with potential for scaling to a wider range of schools in Bhutan. Findings have implications for national teacher professional development policy, scalable training models, and sustainable integration of inclusive digital resources.

Table of Contents

List of Tables

List of Figures

Abbreviations

B.Ed	:	Bachelor of Education
B.Sc	:	Bachelor of Science
CL4STEM	:	Connected Learning for STEM
CLix	:	Connected Learning Initiative
CoP	:	Community of Practice
GPE	:	Global Partnership for Education
HoD	:	Head of Department
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
STEM	:	Science, Technology, Engineering, and Mathematics
STEAM	:	Science, Technology, Engineering, Arts and Mathematics
TISS	:	Tata Institute of Social Sciences
TELD	:	Teacher and Educational Leadership Division
UDL	:	Universal Design for Learning.

Chapter 1: Introduction and Project Context

1.1 Background

Samtse College of Education (SCE) in collaboration with Ibrahim Badamasi Babangida University Lapai (IBBUL), Nigeria, and the Open University of Tanzania (OUT), with technical support from the Tata Institute of Social Sciences (TISS), Mumbai, India, implemented the consortium project titled *Connected Learning for Teacher Capacity Building in STEM (CL4STEM)*. 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. During the Pilot Phase, which spanned from April 2021 to December 2023, the project supported the professional development (PD) of 39 in-service and 43 pre-service STEM teachers using subject specific Open Educational Resources (OER) in a practice-based model. The practice based model enabled teachers to engage actively with the OER module content, apply the learned knowledge and skills by designing and implementing lessons followed by reflection on their classroom practices to improve further. Practice-based PD for teachers emphasises learning through active engagement in real practice settings. This approach has been regarded as more effective than the traditional theory-laden PD model that involves passive learning with limited practical applications and follow up (Bodnar & Zhang, 2024). Practice-based PD models foster continuous practice in a contextually relevant environment, support deeper understanding of pedagogies, and encourage reflection on their teaching practices (Herro et al., 2022; Jeram & Davids, 2020; Osborne et al., 2019).

Based on the achievements of the Pilot Phase, the project was extended from January to December 2024 to support PD of an additional cohort of 145 secondary STEM teachers from 85 middle and higher secondary schools across 20 dzongkhags (districts) in Bhutan.The significant part of this phase was that OER modules were further reviewed in collaboration with the curriculum developers of the Ministry of Education and Skills Development (MoESD). Likewise, teachers' applications were jointly evaluated, and the entire PD of selected teachers was jointly implemented and monitored with the Teacher

and Educational Leadership Division (TELD) under the Department of School Education, MoESD.

Following the successful implementation of the Pilot and Extension phases, the consortium partners were awarded an additional Impact Scaling Grant to expand this initiative to a smaller cohort of teachers. The CL4STEM PD programme initiated in April 2021 was originally conceptualised within the context of STEM education among the partner countries and supported the PD of secondary science and mathematics teachers during the earlier two phases. In the Bhutanese context, it was perceived that exclusion of Arts and Humanities teachers created unequal access to PD opportunities and affected non STEM teachers' morale. Recognising this gap, the present phase adopted an inclusive, whole-school approach by extending PD support to secondary teachers from Arts and Humanities alongside STEM teachers. The framework of the PD was guided by the Universal Design for Learning (UDL) and education technologies for designing flexible learning environments to accommodate learner variability. Accordingly, PD of STEAM teachers was supported using an OER module focused on UDL and educational technology titled, *Transforming Pedagogy with Technology and the Universal Design for Learning Approach in STEAM Education.* Teachers learned to design learner centred flexible learning experiences by integrating technologies and creating inclusive and equitable learning environments.

1.2 Aim:

The aim of this project was to strengthen the professional capacity of Bhutanese secondary STEAM teachers in implementing inclusive, technology integrated learner-centred teaching using UDL principles.

1.3 Specific Objectives:

By the end of the PD programme, participating teachers were expected to:

1. Develop conceptual understanding of UDL principles-multiple means of representation, engagement, and action/expression.
2. Integrate appropriate educational technologies into their classroom practices for supporting diverse learners.
3. Design inclusive lessons using UDL framework for accommodating learner variability.

4. Apply student-centered pedagogical strategies.
5. Enhance assessment practices through technology and UDL framework.
6. Adapt UDL and technology through reflections.
7. Promote collaboration and professional learning through Telegram supported Communities of Practice (CoPs).
8. Generate research-based evidence to inform policy and planning for scaled implementation.

This report comprises five chapters. Chapter 1 introduces the project context, aim, and objectives. Chapter 2 details the methodology, including the study context, demographic profile of the sample schools, participants, and data collection and analysis procedures. Chapter 3 presents quantitative findings on teachers' KAP related to the ICT-enabled, UDL-aligned OER module. Chapter 4 reports qualitative findings, exploring teachers' ICT integration and inclusive practices through the lens of UDL. Chapter 5 synthesises the findings, draws conclusions, discusses implications, limitations, and future directions, and highlights key takeaways for scaling teacher professional development.

Chapter 2: Materials and Methods

2.1 Study Context

This study was part of the impact scaling phase of the CL4STEM project, funded by KIX, the Global Partnership for Education (GPE), and the International Development Research Centre (IDRC), Canada. The aim of this project was to strengthen the professional capacity of Bhutanese secondary Science, Technology, Engineering, Arts, and Mathematics (STEAM) teachers to implement inclusive, ICT-supported, learner-centred teaching practices guided by Universal Design for Learning (UDL) principles.

To achieve this aim, a six-week ICT-based Open Educational Resources (OER) module was implemented. The module was explicitly structured around the three core UDL principles-multiple means of representation, engagement, and expression, and was adaptable across all STEAM subjects, including Dzongkha (national language). Teachers engaged in both conceptual and applied learning activities focused on inclusive pedagogy using ICT-supported OER, providing structured opportunities to develop knowledge, attitudes, and practical skills relevant for classroom integration.

A mixed-methods approach was employed, combining a structured KAP survey administered to all teachers with semi-structured interviews of a purposively sampled subset of participants to capture in-depth experiences and professional practices.

2.2 Demographic Profile of the Sample School

Norbugang Central School is a higher secondary school located in the Norbugang Gewog (village block) of Samtse Dzongkhag (district). The approximate distance of Norbugang Central School from the Samtse Dzongkhag Administration is 11 km. It is a government school established in 2028 and functions as a semi-urban school with co-educational boarding facilities. It offers secondary education from Grade VII to Grade XII. There are 48 full-time teachers and 6 support staff. English is the medium of instruction for all subjects except Dzongkha, the national language of Bhutan which is taught in Dzongkha. The majority of students also communicate in their community dialect *Lhotshamkha* when they are outside of school.

2.2.1 Leadership and Professional Capacity

In Bhutan, a school is administered by a Principal selected through a competitive interview by the Ministry and endorsed by the Royal Civil Service Commission (RCSC). The Principal is normally supported by two Vice Principals, also selected through open competition by the Ministry and takes care of academic and non-academic matters of the school. Academic matters include scheduling classes and examinations, curriculum planning and implementation, teacher supervision, professional development, monitoring and evaluation of students' performance, student discipline and behavior management, health, safety and counselling programmes, academic resources management, and complying the school academic activities with national education standards. Non-academic matters include managing school mess, school infrastructure and maintenance, welfare programmes, extracurricular activities, and budgeting and finance. Overall, the District Education Officer (DEO), based at the district administrative office, provides oversight of the governance and activities of schools within a district.

The Norbugang Central School is headed by an experienced Principal, who has a Master's Degree in Education (M. Ed) along with 35 years of teaching experience and 34 years of school leadership and administration experiences. He is supported by a Vice Principal, 48 teachers and 6 support staff in the daily operations of the school.

2.2.2 Physical Infrastructure and Academic Resources

The school campus is accessible by an all-weather road. The school has separate all-weather academic and hostel buildings, administrative spaces including a staff room, principal's and vice principal's offices. The campus has a playground that supports physical education, sports, and recreational activities for students and staff. The school has enough classrooms, ICT and science laboratories, library, multipurpose hall, and separate hostels for boys and girls. Students from far off places (beyond 5 Km) are accommodated as boarders while nearby community students attend schools as dayscholars. The school ensures availability of such as safe drinking water and separate sanitation facilities for male and female students. The school mess provides balanced and nutritious meals to boarding students further supplemented with milk and eggs in addition to regular meals. The school also maintains a kitchen garden for supporting practical learning and nutrition education.

Source: Namgay Phuntsho, Google Photo

2.2.3 Digital Readiness and ICT Integration

In terms of technology, Norbugang Central School has made significant developments in integrating ICT into its academic programmes. The school is equipped with desktops, smart boards, smart televisions, printers, scanners, and copiers. The school has an internet connectivity of 11 Mbps. However, with the developing industries in the Norbugang Gewog, the school now experiences frequent power outages that disrupt classroom teaching and learning and affect room conditioning facilities. Connectivity is relatively stable, with electricity and internet (averaging 11 Mbps) available most of the time. All teachers own personal laptops and smart phones. Since the school caters to students mostly from rural areas around 60% of the students have access to smart phones.

2.2.4 Student Welfare and Support Services

In Bhutan, a Central School is a government supported public school that normally has boarding facilities, enhanced infrastructure to deliver quality, inclusive, equitable and holistic education to the community students. As a central school, it provides a variety of free services including daily meals, uniforms, and textbooks, health check-ups and free transport. These initiatives ensure that

students, particularly those in the boarding facilities, can focus entirely on their academic and personal development without financial strain.

2.3 Participants Characteristics

The study involved 31 teachers from one Higher Secondary School, representing a variety of age groups and teaching different school subjects. This comprehensive inclusion ensured representation across all subject areas offered at the school, reflecting the diversity of teaching responsibilities and professional experiences among participants.

Table 2.1 presents the gender and age distribution of the participants, while Table 2.2 presents their academic qualifications and teaching subjects. Most teachers held a PGDE (Postgraduate Diploma in Education), followed by B.Ed (Secondary), with a smaller proportion possessing a master's degree or higher. In terms of teaching areas, participants represented a broad disciplinary spread, and distribution reflected balanced representation across core secondary school subjects relevant to the intervention.

Table 2.1 *Gender and Age Distribution of Participants*

Gender	Age				Total	Percentage (%)
	21 - 30	31 - 40	41 - 50	Above 50		
Male	-	8	3	4	15	48.4
Female	9	7	-	-	16	51.6
Total	9	15	3	4	31	100

Table 2.2 *Participants' Qualifications and Teaching Subject Categories (N = 31)*

Variable	Category	n	Current teaching Subjects
Highest Qualification	B.Ed (Secondary)	10	-
	PGDE	13	-
	M.Ed / Master's	7	-
	PhD	1	-
	Total	**31**	-
Teaching Subject Area	Languages	8	English, Dzongkha
	Sciences, ICT & Mathematics	15	Physics, Chemistry, Biology, HPE, Mathematics, Science & ICT
	Social Sciences	8	Geography, Economics, History
	Total	**31**	

Note: n = number of participants. Subject areas were grouped for reporting clarity.

2.3 Study Design

A quasi-experimental pre-post design was employed to evaluate the effectiveness of the ICT-based OER module. This design enabled the examination of changes in teachers' knowledge, attitudes, and practices (KAP) in relation to inclusive, learner-centred, ICT-supported teaching, without a control group.

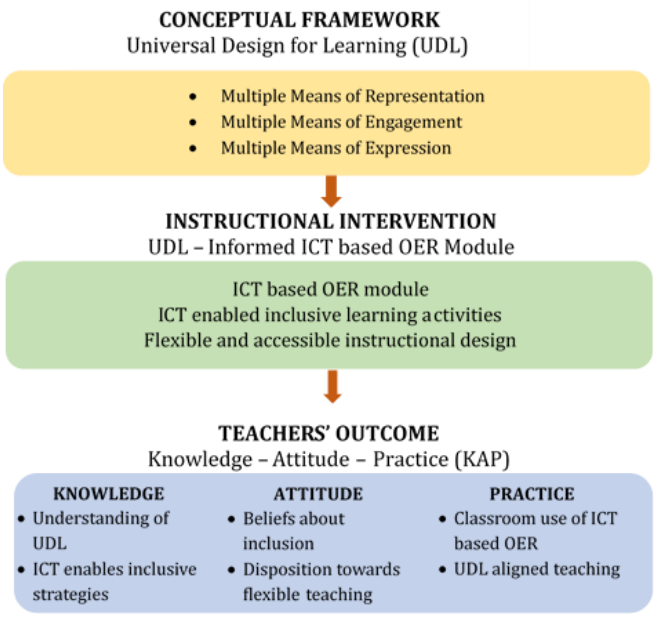
The design combined quantitative assessment of KAP scores for all participants with a qualitative component involving semi-structured interviews of a purposively sampled subset, allowing exploration of teachers' experiences and practices in depth.

2.4 Conceptual Framework of the Study

The conceptual framework (Figure 2.1) illustrates how an ICT-based OER module grounded in UDL principles influences teachers' KAP in inclusive, learner-centred pedagogy. UDL principles were selected because they provide a well-established, evidence-based framework for designing instruction that meets the diverse needs of learners, enabling teachers to plan, deliver, and assess lessons in ways that are accessible, engaging, and flexible for all students.

The framework guided both quantitative measurement of KAP scores and qualitative exploration of teachers' experiences, capturing both the extent and depth of changes in professional practices.

Figure 2.1 Conceptual framework



2.4.1 Assumed Relationship

Participation in an ICT-based OER module grounded in UDL principles is assumed to lead to improvements in teachers' KAP, thereby strengthening their capacity to design and implement inclusive, learner-centred instruction across all subjects.

2.5 Intervention Design and Implementation

The six-week ICT-based OER module was delivered in a structured manner to support teachers' professional development in line with UDL principles.

- **Multiple Means of Representation:** Teachers were exposed to online OER presented in diverse formats, including text, visuals, multimedia, and digital learning materials, demonstrating how content can be made accessible for different learners.
- **Multiple Means of Engagement:** Teachers participated in interactive tasks, collaborative activities, and reflective exercises designed to foster engagement and motivation.
- **Multiple Means of Expression:** Teachers observed examples of varied instructional outputs and classroom applications to understand how learners can demonstrate knowledge in multiple ways.

The module combined conceptual instruction on UDL with guided activities, demonstrations, and discussions. Emphasis was placed on practical application, enabling teachers to integrate UDL-aligned strategies and ICT-supported resources into their own lesson planning and classroom practice.

2.6 Research Instrument

2.6.1 Quantitative

Quantitative data were collected using a structured survey aligned with UDL principles, comprising three core principles (Representation, Engagement, Expression), three domains per principle (Knowledge, Attitude, Practice), and five items per domain. Responses were recorded on a five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).

Reliability Assessment: The internal consistency of the survey instrument was assessed using Cronbach's alpha at baseline and endline to ensure stable measurement of teachers' KAP across the intervention. Specific Cronbach's alpha values are reported in the Results chapter.

2.6.2 Qualitative Data Collection and Analysis

Semi-structured interviews were conducted with six purposefully sampled teachers representing Science, Mathematics, Arts, and Humanities subjects, ensuring coverage of core STEAM disciplines.

- Baseline interviews explored existing teaching practices, the status of integrating educational technologies, and challenges faced.
- Endline interviews examined changes in practices, experiences, and reflections following the implementation of the OER module.

All interviews were audio-recorded and transcribed using Microsoft 365. Data were analysed thematically, with responses coded to identify common themes, providing a detailed understanding of changes in teachers' KAP after participating in the intervention.

2.7 Data Collection Procedures

The KAP survey was administered at two time points: baseline (prior to the intervention) and endline (after completion of the six-week module). Items were mapped to multiple means of representation, engagement, and expression across KAP domains. This structure enabled a principle-based assessment of teachers' professional development in alignment with the study aim.

2.8 Indicators and measures

Key indicators included domain-wise mean scores for teachers' KAP under each UDL principle. These indicators captured teachers' knowledge, attitudes, and self-reported practices related to the use of ICT-enabled, UDL-aligned Open Educational Resources to support inclusive, learner-centred teaching and learning. Changes between baseline and endline scores were examined to assess improvements associated with the intervention across the UDL principles.

2.9 Data analysis

Quantitative data were analysed using SPSS. Descriptive statistics (means and standard deviations) summarised KAP scores across the three UDL principles. Data were screened for accuracy, and normality assumptions were assessed using the Kolmogorov–Smirnov and Shapiro-Wilk tests.

Paired-samples *t*-tests were conducted to determine whether differences between baseline and endline mean scores were statistically significant. Mean differences (ΔM) were calculated to indicate the magnitude and direction of change.

Qualitative interview data were analysed thematically, with coding used to identify common patterns and themes. Results are reported in the Results chapter.

2.10 Ethical considerations

Institutional approval was obtained from the relevant school authorities prior to implementation. Teachers were informed of the purpose of the study and the nature of the data being collected. Confidentiality and anonymity were maintained by removing personal identifiers, and all data were analysed and reported in aggregate form. Participation was part of routine professional development activities, and data were used exclusively for project evaluation and reporting.

2.11 Limitations

Although the quasi-experimental pre-post design facilitated the assessment of changes associated with the intervention, the absence of a control group limits causal attribution. In addition, as data collection occurred within an institutional professional development context where participation was not voluntary, responses may have been influenced by social desirability or compliance effects. Nevertheless, the close alignment between the ICT module, OER development, and UDL principles strengthens the interpretive value of the findings within the Bhutanese secondary education context.

Chapter 3: Quantitative Findings

3.1 Overview of the Analytical Framework

This chapter presents the results of the baseline and endline survey administered to teachers following the six-week implementation of the ICT-based Open Educational Resources (OER) module aligned with Universal Design for Learning (UDL) principles. The analysis followed the structure of the survey instrument, which examined three UDL principles-Multiple Means of Representation, Multiple Means of Engagement, and Multiple Means of Expression-across the domains of Knowledge, Attitude, and Practice.

Descriptive statistics, including means and standard deviations, were used to summarise baseline and endline KAP scores. Normality of the score distributions was assessed using the Shapiro–Wilk test, with results presented in tabular form. Based on the outcomes of the normality test, paired-samples *t*-tests were conducted for domains that met normality assumptions, while Wilcoxon signed-rank tests were applied for domains where assumptions were violated.

Effect sizes were calculated using Cohen's *d* to quantify the magnitude of baseline-endline changes. The direction and consistency of change across participants were also examined to strengthen interpretation of the intervention's effects.

3.2 Reliability of the Survey Instrument

Internal consistency reliability of the survey instrument was assessed using Cronbach's alpha for the overall scale and for each KAP domain across the three UDL principles at both baseline and endline.

The KAP questionnaire demonstrated excellent overall reliability at both baseline (Cronbach's $\alpha = 0.94$) and endline ($\alpha = 0.97$) across all 45 items (Table 3.1). Domain-level analyses within each UDL theme showed acceptable to excellent internal consistency, with baseline alpha-values ranging from 0.650 to 0.895 and endline values improving to 0.684–0.907 (Table 3.2).

Table 3.1 *Overall Reliability Statistics of the KAP Questionnaire (N = 31)*

Datatype	Cronbach's Alpha	No of Items
Baseline (n=31)	0.94	45
Endline (n=31)	0.97	45

Table 3.2 *Theme and Domain wise Reliability Statistics (Cronbach's Alpha)*

UDL theme	Domain	Baseline (n=31)	Endline (n=31)	No. of Items
Representation	Knowledge	.676	.684	5
	Attitude	.790	.839	5
	Practice	.742	.892	5
Engagement	Knowledge	.806	.782	5
	Attitude	.805	.781	5
	Practice	.650	.803	5
Expression	Knowledge	.823	.860	5
	Attitude	.784	.906	5
	Practice	.895	.907	5

Key Findings:

- The KAP survey demonstrated excellent overall reliability at both baseline (α = 0.94) and endline (α = 0.97), indicating consistent measurement across all 45 items.
- Domain-level analyses across the three UDL principles showed acceptable to excellent internal consistency**,** with baseline α-values ranging from 0.650 to 0.895 and endline values improving to 0.684–0.907, reflecting enhanced reliability of responses over time.

3.3 Descriptive Trends in Teachers' KAP Scores

Teachers' scores on KAP domains showed consistent improvement across all UDL themes following the six-week intervention. At the domain level (Table 3.3), Knowledge increased by 0.73–1.03 points, Attitude by 0.32–0.49 points, and Practice by 0.63–1.06 points, indicating gains in both understanding and application of UDL principles. Overall mean scores (Table 3.4) reflected similar trends, with Knowledge improving from 3.74 (SD = 0.50) to 4.58 (SD = 0.38; ΔM = +0.84), Attitude from 4.27 (SD = 0.42) to 4.71 (SD = 0.36; ΔM = +0.44), and Practice from 3.67 (SD = 0.55) to 4.45 (SD = 0.49; ΔM = +0.78).

These results indicate that the intervention had a positive effect on teachers' KAP related to UDL.

Table 3.3 *Teacher KAP Scores at Baseline and Endline by Themes and Domains*

UDL Themes	*Domains*	Baseline M (SD)	Endline M (SD)	Change (ΔM)
Representation	Knowledge	3.83 (0.55)	4.59 (0.42)	+0.76
	Attitude	4.45 (0.49)	4.77 (0.38)	+0.32
	Practice	3.93 (0.55)	4.56 (0.48)	+0.63
Engagement	Knowledge	3.92 (0.57)	4.65 (0.36)	+0.73
	Attitude	4.19 (0.50)	4.66 (0.42)	+0.47
	Practice	3.88 (0.48)	4.54 (0.44)	+0.66
Expression	Knowledge	3.46 (0.60)	4.49 (0.51)	+1.03
	Attitude	4.19 (0.50)	4.68 (0.44)	+0.49
	Practice	3.20 (0.85)	4.26 (0.71)	+1.06

Note. KAP = Knowledge, Attitude, Practice; SD = Standard Deviation. Baseline scores collected before the 6-week UDL intervention; Endline scores collected immediately after intervention.

Table 3.4 *Overall M, SD, and ΔM of teachers' KAP across UDL domains at baseline and endline.*

Domain	Baseline M (SD)	Endline M (SD)	Change(ΔM)
Knowledge	3.74 (0.50)	4.58 (0.38)	+0.84
Attitude	4.27 (0.42)	4.71 (0.36)	+0.44
Practice	3.67 (0.55)	4.45 (0.49)	+0.78

Note. KAP = Knowledge, Attitudes, and Practices; UDL = Universal Design for Learning; M = Mean; SD = Standard Deviation; ΔM = Change in Mean.

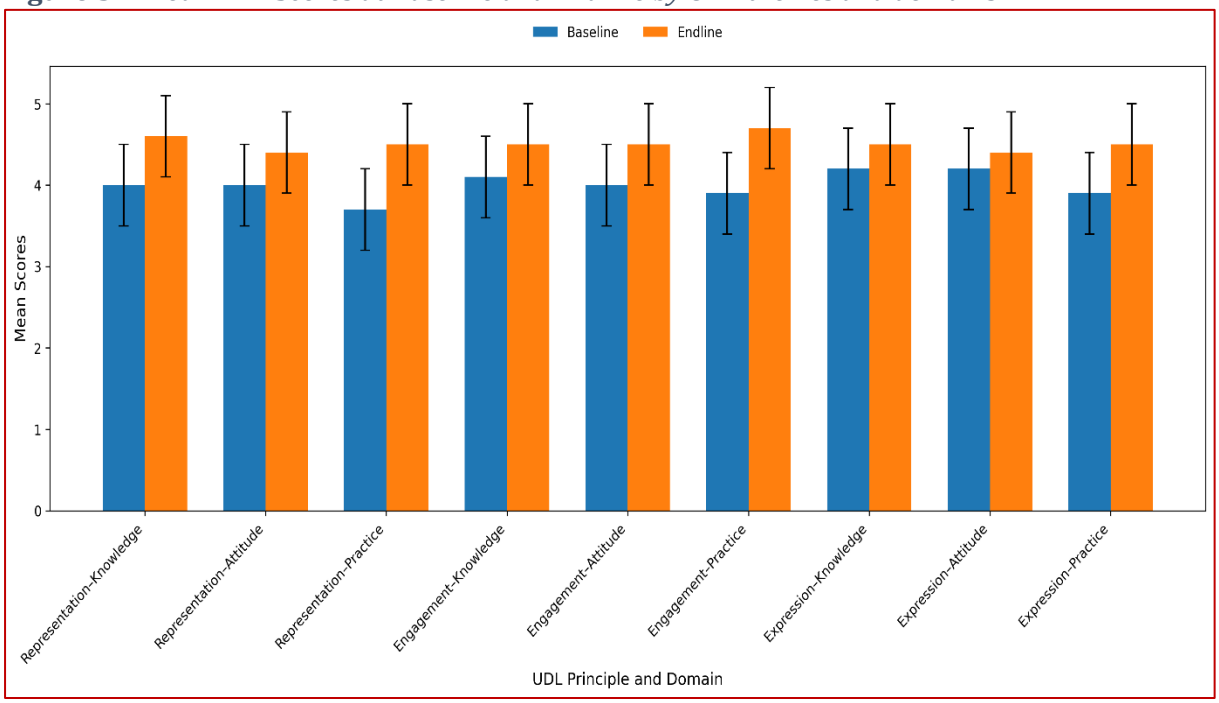
Key Findings:

- Teachers' KAP scores improved consistently across all UDL themes following the six-week intervention.
- Knowledge gains ranged from 0.73–1.03 points at the domain level (overall ΔM = 0.84), indicating strengthened understanding of UDL principles.
- Attitude scores increased by 0.32–0.49 points (overall ΔM = 0.44), reflecting sustained positive perceptions toward inclusive, learner-centred teaching.
- Practice improvements ranged from 0.63–1.06 points (overall ΔM = 0.78), demonstrating enhanced application of UDL strategies in classroom settings.

3.4 Descriptive Statistics of Baseline-Endline Differences by UDL Principles and Domains

Figure 3.1 visually represents the mean KAP scores of teachers at baseline and endline across UDL themes and domains, highlighting changes observed following the intervention.

Figure 3.1 *Mean KAP Scores at Baseline and Endline by UDL themes and domains*



3.4.1 Multiple Means of Representation

Item-wise analysis showed consistent baseline–endline improvements across Knowledge, Attitude, and Practice items related to multiple means of representation (Tables 3.5 – 3.7). Knowledge gains ranged from ΔM = 0.59–1.09, with the largest increase in teachers' understanding of strategies to emphasise key concepts for diverse learners. Practice items demonstrated moderate to strong gains (ΔM = 0.42–0.81), particularly in integrating ICT tools to present content in multiple formats. Attitudes showed smaller positive changes (ΔM = 0.19–0.51), reflecting high baseline perceptions. Overall, these results indicate strengthened teacher capacity to design accessible and varied instructional representations.

Table 3.5 *Item-wise Baseline-Endline mean scores for teachers' Knowledge related to Multiple Means of Representation*

Codes	Items	Baseline	Endline	Mean Diff.
		M (SD)	M(SD)	
T1K1	I understand the Universal Design for Learning (UDL) principle of providing multiple ways to present information (e.g., text, diagrams, videos etc.).	4.06 (0.96)	4.65 (0.49)	0.59
T1K2	I know how to structure content to make it accessible for all students (e.g., summaries, headings, visuals etc	3.71 (0.74)	4.52 (0.57)	0.81
T1K3	I am aware of ICT tools that support varied content delivery (e.g., PowerPoint, YouTube, Canva.com etc.).	3.97 (0.75)	4.61 (0.84)	0.64
T1K4	I understand strategies to emphasize key concepts for diverse learners (e.g., infographics, concept maps etc.).	3.52 (0.89)	4.61 (0.56)	1.09
T1K5	I understand how combining different presentation modes enhances comprehension for all learners	3.87 (0.81)	4.58 (0.62)	0.71

Note: T1 represents Theme 1 (UDL principle Multiple Means of Representation), and K1–K5 denote the Knowledge items belonging to T1.

Table 3. 6 *Item-wise Baseline-Endline mean scores for teachers' Attitude related to Multiple Means of Representation*

Codes	Items	Baseline	Endline	Mean Diff.
		M (SD)	M(SD)	
T1A1	Providing content in multiple formats improves student understanding.	4.45 (0.81)	4.77 (0.43)	0.32
T1A2	Designing lessons with varied materials supports diverse learners.	4.39 (0.8)	4.90 (0.3)	0.51
T1A3	Using ICT tools improve content representation (e.g., interactive videos, digital slides etc.).	4.61 (0.5)	4.81 (0.48)	0.2
T1A4	Multiple representations accommodate students with different learning abilities.	4.55 (0.51)	4.74 (0.51)	0.19
T1A5	I am motivated to apply the UDL multiple means of representation in my teaching	4.23 (0.67)	4.65 (0.66)	0.42

Note: T1 represents Theme 1 (UDL principle Multiple Means of Representation), and A1–A5 denote the Attitude items belonging to T1.

Table 3.7 *Item-wise Baseline-Endline mean scores for teachers' Practice related to Multiple Means of Representation*

Codes	Items	Baseline	Endline	Mean Diff.
		M (SD)	M(SD)	
T1P1	I use images, videos, or audio to explain concepts (e.g., YouTube clips, PowerPoint visuals etc.).	4.32 (0.6)	4.74 (0.44)	0.42
T1P2	I provide supplementary materials for different learning preferences (e.g., handouts, audio notes etc.).	3.94 (0.96)	4.52 (0.63)	0.58
T1P3	I adapt lesson content (e.g., simplified text, translated materials etc.) to cater to diverse learners.	3.9 (0.54)	4.52 (0.57)	0.62
T1P4	I integrate ICT tools and resources to present content in multiple ways (e.g., interactive simulations, digital charts etc.).	3.71 (0.78)	4.52 (0.57)	0.81
T1P5	I assess student understanding using varied presentation methods (e.g., quizzes, discussions, visual summaries etc.).	3.77 (0.96)	4.52 (0.63)	0.75

Note: T1 represents Theme 1 (UDL principle Multiple Means of Representation), and P1–P5 denote the Practice items belonging to T1.

Key Findings

- Knowledge and practice improvements suggest increased adoption of inclusive, ICT-supported instructional approaches.
- Positive baseline attitudes were maintained, supporting motivation to apply UDL principles.

3.4.2 Multiple Means of Engagement

Baseline–endline comparisons revealed consistent improvements across all KAP domains for engagement (Tables 3.8–3.10). Knowledge gains were moderate (ΔM = 0.55–0.87), notably in strategies to enhance student motivation and participation. Attitudes increased modestly (ΔM = 0.26–0.65), consistent with high initial endorsement. Practice items showed the largest gains (ΔM = 0.33–1.23), particularly in using ICT tools to promote participation and learner choice.

Table 3.8 *Item-wise Baseline-Endline mean scores for teachers' Knowledge related to Multiple Means of Engagement*

Codes	Items	Baseline	Endline	Mean Diff.
		M (SD)	M(SD)	
T2K1	I understand the UDL principle of offering multiple ways to engage students (e.g., group work, polls etc.).	3.90 (0.79)	4.68 (0.48)	0.78
T2K2	I know strategies to enhance student motivation and participation (e.g., games, choice boards etc.).	3.61 (0.95)	4.48 (0.57)	0.87
T2K3	I am aware of how providing choices impacts engagement (e.g., selecting projects or activities etc.).	4.03 (0.71)	4.68 (0.48)	0.65
T2K4	I know methods to encourage collaboration among students (e.g., peer review, group projects etc.).	3.94 (0.68)	4.71 (0.46)	0.77
T2K5	I understand how feedback maintains student engagement (e.g., instant quiz verbal comments etc.).	4.13 (0.62)	4.68 (0.48)	0.55

Note: T2 represents Theme 2 (UDL principle Multiple Means of Engagement), and K1–K5 denote the Knowledge items belonging to T2.

Table 3.9 *Item-wise Baseline-Endline mean scores for teachers' Attitude related to Multiple Means of Engagement*

Codes	Items	Baseline	Endline	Mean Diff.
		M (SD)	M(SD)	
T2A1	Offering choices in learning activities increases student motivation.	4.39 (0.50)	4.81 (0.40)	0.42
T2A2	Interactive activities promote active participation (e.g., Kahoot, Quizizz etc.).	4.23 (0.67)	4.68 (0.54)	0.45
T2A3	ICT tools facilitate student engagement (e.g., Google Docs, Padlet etc.).	4.00 (0.73)	4.65 (0.49)	0.65
T2A4	Collaborative tasks enhance interest and involvement (e.g., Google Docs, Padlet, board etc.).	3.97 (0.66)	4.58 (0.56)	0.61
T2A5	A responsive learning environment keeps students motivated and engaged.	4.35 (0.55)	4.61 (0.56)	0.26

Note: T2 represents Theme 2 (UDL principle Multiple Means of Engagement), and A1–A5 denote the Attitude items belonging to T2.

Table 3.10 *Item-wise Baseline-Endline mean scores for teachers' Practice related to Multiple Means of Engagement*

Codes	Items	Baseline	Endline	Mean Diff.
		M (SD)	M(SD)	
T2P1	I use ICT tools (e.g., Slido, Kahoot, Quizizz, Padlet) to increase student participation.	3.16 (1.00)	4.39 (0.67)	1.23
T2P2	I provide students with options in learning tasks (e.g., topic selection, project formats etc.).	3.77 (0.76)	4.45 (0.62)	0.68
T2P3	I implement collaborative activities (e.g., group work, group project etc.).	4.35 (0.55)	4.68 (0.48)	0.33
T2P4	I provide timely constructive feedback to guide students' progress (e.g., comments on assignments, quiz results etc.).	4.03 (0.66)	4.68 (0.54)	0.65
T2P5	I monitor engagement and adjust activities to sustain students' interest (e.g., shifting from lecture to interactive tasks).	4.10 (0.65)	4.52 (0.63)	0.42

Note: T2 represents Theme 2 (UDL principle Multiple Means of Engagement), and P1–P5 denote the Practice items belonging to T2.

Key Findings:

- The intervention effectively strengthened teachers' ability to design interactive and motivating learning environments.
- Gains in knowledge and practice reflect improved capacity to implement UDL-aligned engagement strategies.

3.4.3 Multiple Means of Expression

Substantial improvements were observed across KAP domains for expression (Tables 3.11–3.13). Knowledge gains ranged from ΔM = 0.78–1.45, with the largest increase in understanding how to assess students digitally (T3K4). Practice gains were pronounced (ΔM = 0.46–1.38), particularly in using ICT for creative assignments and providing audio- or video-based feedback. Attitudes showed smaller positive changes (ΔM = 0.39–0.59), reflecting already favourable baseline perceptions.

Table 3.11 *Item-wise baseline-endline mean scores for teachers' Knowledge related to Multiple Means of Expression*

Codes	Items	Baseline	Endline	Mean Diff.
		M (SD)	M(SD)	
T3K1	I understand the UDL principle of providing multiple ways for students to express learning (e.g., written, oral, infographic, blogging, poster, etc).	3.77 (0.72)	4.55 (0.57)	0.78
T3K2	I know diverse assessment methods beyond traditional tests (e.g., projects, presentations, digital portfolios, blogging).	3.48 (0.68)	4.55 (0.51)	1.07
T3K3	I am aware of ICT tools that can help students in expressing their learning (e.g., Google Slides, Canva, iMovie).	3.58 (0.85)	4.55 (0.57)	0.97
T3K4	I understand how to assess the student's work digitally (e.g., recorded voice feedback, video recorded feedback, etc).	2.90 (0.91)	4.35 (0.75)	1.45
T3K5	I know strategies to guide students in expressing their learning creatively (e.g., storytelling, videos, infographics).	3.55 (0.77)	4.45 (0.72)	0.9

Note: T3 represents Theme 3 (UDL principle Multiple Means of Expression), and K1–K5 denote the Knowledge items belonging to T3.

Table 3.12 *Item-wise baseline-endline mean scores for teachers' Attitude related to Multiple Means of Expression*

Codes	Items	Baseline	Endline	Mean Diff.
		M (SD)	M(SD)	
T3A1	Allowing students to express learning in multiple formats improves understanding.	4.32 (0.54)	4.77 (0.43)	0.45
T3A2	Creative assessment methods enhance student engagement (e.g., role-plays, videos, blogs).	4.13 (0.62)	4.61 (0.56)	0.48
T3A3	ICT tools support diverse ways of expression (e.g., Canva.com, blogger.com, Padlet, Flipgrid).	4.06 (0.63)	4.65 (0.49)	0.59
T3A4	Offering varied assessment methods promotes fairness for all learners.	4.13 (0.88)	4.68 (0.54)	0.55
T3A5	I am motivated to provide multiple ways for students to demonstrate their learning.	4.29 (0.69)	4.68 (0.54)	0.39

Note: T3 represents Theme 3 (UDL principle Multiple Means of Expression), and A1–A5 denote the Attitude items belonging to T3.

Table 3.13 *Item-wise baseline-endline mean scores for teachers' Practice related to Multiple Means of Expression*

Codes	Items	Baseline	Endline	Mean Diff.
		M (SD)	M(SD)	
T3P1	I allow students to submit work in different formats (e.g., videos, presentations, reports).	3.77 (0.88)	4.23 (0.92)	0.46
T3P2	I use ICT tools to facilitate creative assignments (e.g., Canva, Google Docs, iMovie etc.).	3.10 (0.94)	4.32 (0.79)	1.22
T3P3	I assess students using audio recorded feedback, video recorded feedback and file attached feedback.	2.81 (1.05)	4.19 (0.83)	1.38
T3P4	I guide students in selecting formats to showcase their learning. (e.g., video, poster, essay etc.).	3.26 (1.09)	4.26 (0.77)	1.00
T3P5	I provide feedback through varied modes of student expression (e.g., comments on slides, video feedback etc.)	3.06 (1.06)	4.29 (0.82)	1.23

Note: T3 represents Theme 3 (UDL principle Multiple Means of Expression), and P1–P5 denote the Practice items belonging to T3.

Key Findings

- Multiple means of expression showed the strongest impact, highlighting improved teacher capacity to offer varied assessment formats and feedback mechanisms.
- These changes suggest enhanced readiness to implement equitable, learner-centred assessment aligned with UDL principles.

Having examined item-wise changes across the three UDL principles, the overall assessment of teachers' lesson plans and reflective narratives provides a complementary view of performance patterns at the participant level.

3.5 Descriptive Statistics of Lesson Plans and Reflection

Figures 3.2 and 3.3 depict the frequency distribution of teachers' lesson plan and reflection performance categories (N = 33), showing the number of teachers classified within each evaluation level. Lesson plans and reflections were assessed using an analytic rubric comprising five criteria each, rated on a four-point scale: Need Improvement (0–0.9), Satisfactory (1–1.9), Good (2–2.9), and Excellent (3–4), ensuring objective and consistent assessment. Gender-wise analysis (Figure 3.3) revealed minimal disparity between male and female participants.

In lesson plan evaluation, 28 teachers achieved 'Excellent' and the remaining 5 were rated 'Good,' with no teachers falling into lower categories, reflecting consistent mastery of UDL-aligned lesson design. Both male (15) and female (14) teachers achieved Excellent ratings, indicating uniform competence across learning outcomes, UDL integration, ICT use, and inclusion. In reflections, female participants performed slightly better, with 10 achieving Excellent ratings versus 8 males, and fewer Satisfactory ratings (1 vs. 4), suggesting greater depth, clarity, and organization in articulating learner responses and forward planning.

Figure 3.2 *Frequency Distribution of Teachers' Lesson Plan and Reflections Performance (N = 33)*

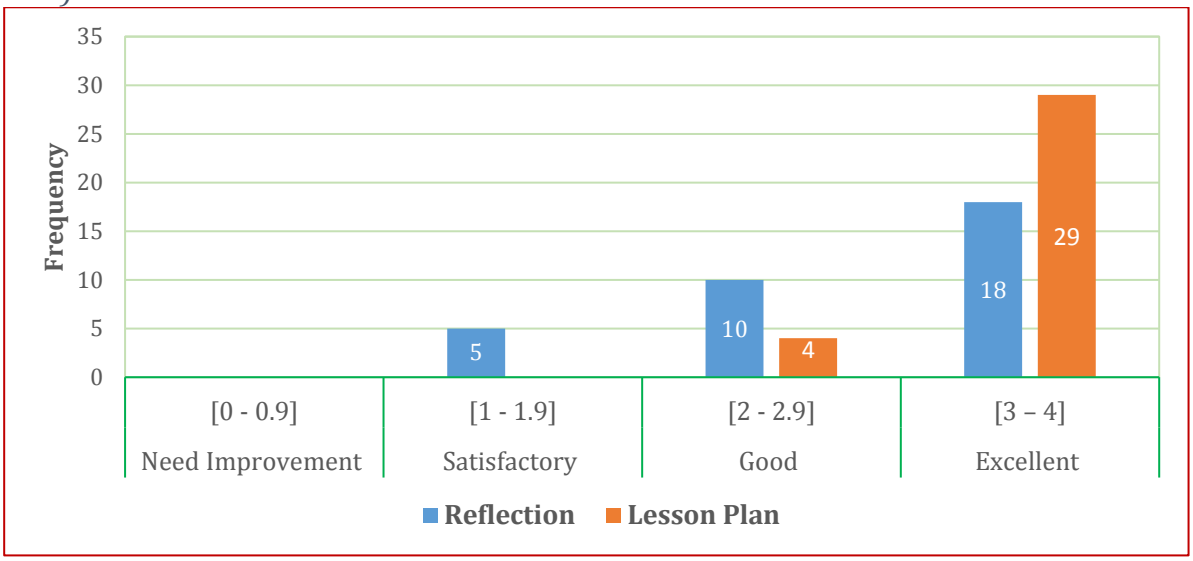
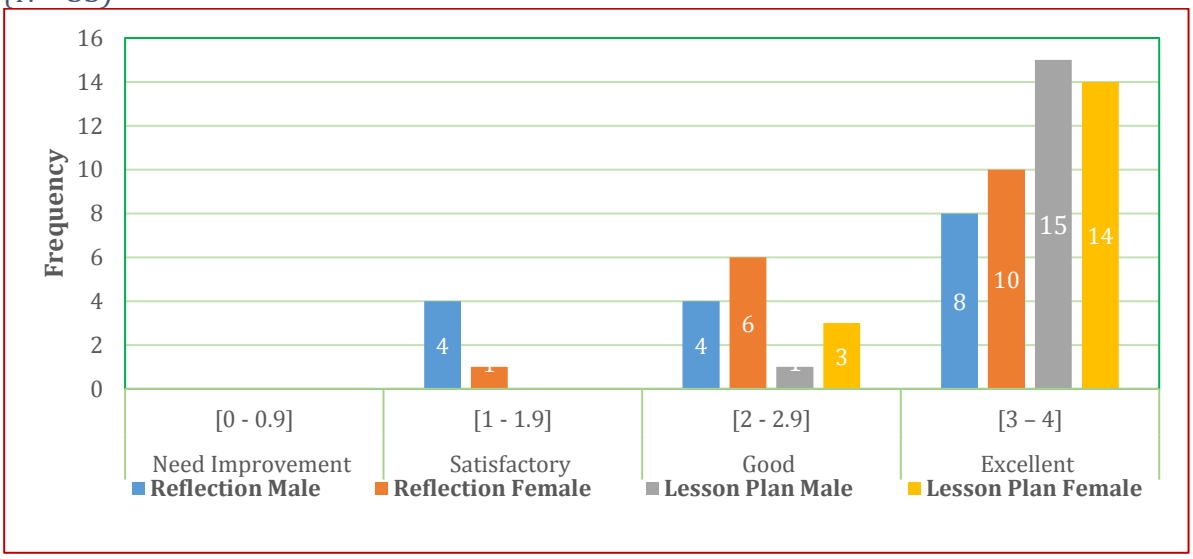


Figure 3.3 *Gender-wise Distribution of Teachers' Lesson Plans and Reflections Performance (N = 33)*



Key Findings

- **Lesson Plan Performance:** Almost all teachers achieved 'Excellent' or 'Good' ratings, reflecting strong UDL-aligned lesson design and inclusive practices.
- **Reflection and Gender Insights:** Female teachers showed slightly stronger reflective performance, while overall gender differences were minimal, indicating consistent competence across participants.

Impression

Overall, teachers demonstrated high achievement across lesson plans and reflections. Competency in UDL-aligned lesson planning was excellent, and reflective practice was strong, though reflection remains an area for further refinement. These results indicate effective project implementation, particularly the professional development sessions and OER-based support, which enhanced teachers' capacity to design inclusive, learner-centred lessons. Gender-equitable performance reinforces the inclusivity and impact of the instructional approach.

Overall Impression of the Descriptive Analyses

The intervention was associated with consistent improvements in teachers' KAP across all UDL principles, with the largest gains in knowledge and practice domains. Improvements were most evident in lesson planning and varied instructional/assessment strategies, while attitudes remained high at baseline. Collectively, these findings suggest strengthened teacher readiness to adopt UDL-aligned practices.

To determine whether the observed baseline-endline differences are statistically significant, the following section 3.6 presents the results of inferential analyses.

3.6 Tests of Normality and Inferential Statistics

3.6.1 Test of Normality

Baseline and endline data were assessed for normality using the Shapiro–Wilk test, supplemented with Q–Q plots and boxplots (Figure 3.4). While endline scores showed some deviation from normality ($W = .900$, $p = .007$), the baseline–endline differences

were normally distributed (W = .973, p = .615), supporting the use of a paired-samples t-test to evaluate intervention effects (Table 3.14).

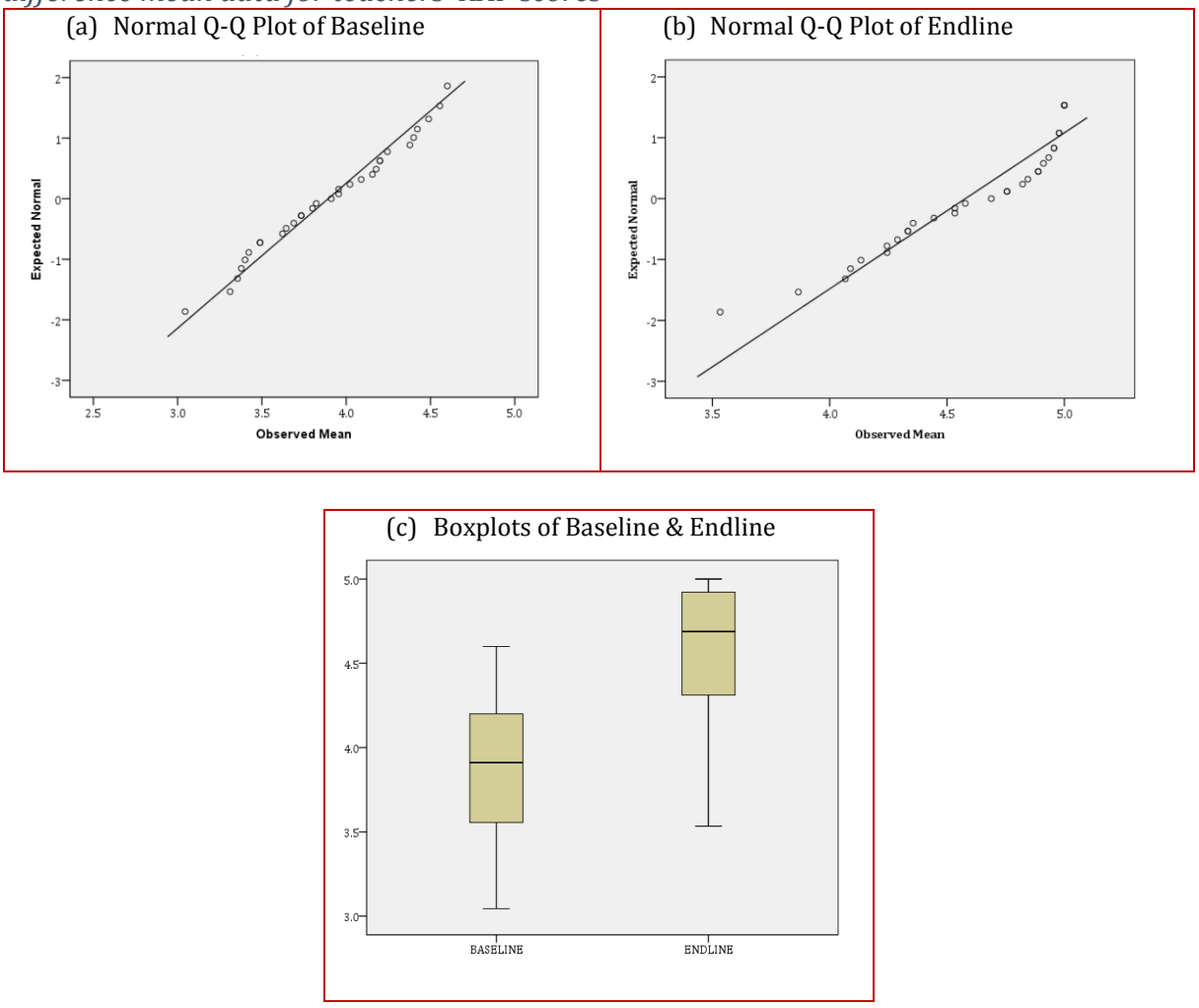
Table 3.14 *Tests of Normality for Baseline and Endline Measures*

Dataset	N	*Statistic (W)*	*df*	*p-value*	Interpretation
Baseline	31	.970	31	.510	Normally Distributed
Endline	31	.900	31	.007*	Non-Normal
Difference	31	.973	31	.615	Normally Distributed

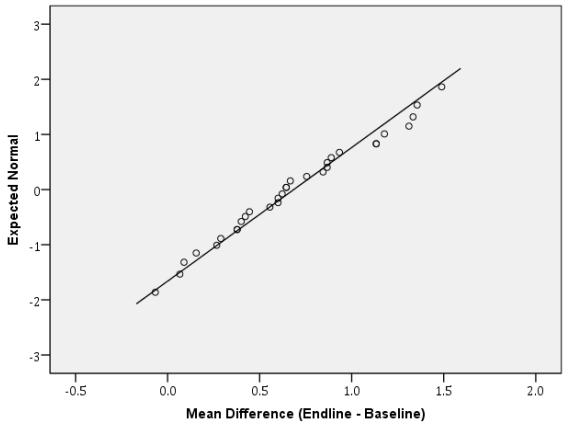
Note. W= Shapiro-Wilk Statistic; df = degrees of freedom. Significance level set at $\alpha = .05$.

Visual inspection via Q-Q plots and boxplots confirmed approximate normality for baseline and difference scores, while endline data showed mild skewness. These results justified the use of paired-samples t-tests to examine baseline–endline changes in teachers' KAP.

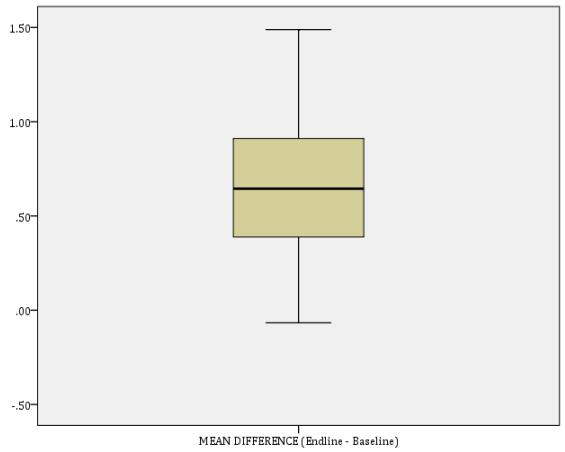
Figure 3.4 *Q-Q plots and Boxplots showing the distribution of baseline, endline, and difference mean data for teachers' KAP scores*



(d) Normal Q-Q Plot of Mean Difference



(e) Boxplot of Mean Difference



3.6.2 Inferential Analysis

Paired-sample *t*-tests were conducted to examine changes in teachers' KAP between baseline and endline. Effect sizes (Cohen's d) were calculated to quantify the magnitude of observed changes.

3.6.2.1 Paired-Samples t-Tests

The results (Table 3.15) indicate that teachers' scores across all UDL themes (T1, T2, T3) and KAP domains (Knowledge, Attitude, Practice) increased significantly from baseline to endline. All comparisons yielded statistically significant improvements ($p < .001$), with mean differences ranging from 0.37 to 1.05. The largest gains were observed in Knowledge and Practice within the T3 (Expression) theme, while Attitude showed comparatively smaller, yet significant, improvements across all themes.

Table 3.15 *Paired-Samples t-Test Results Comparing Baseline and Endline Scores Across UDL Themes and KAP Domains (N = 31)*

Comparison	*Mean Diff.*	*SD*	*t-test*	*df*	*p-value*
T1 Knowledge (Endline-Baseline)	0.78	0.47	9.22	*30*	<.001
T1 Attitude (Endline-Baseline)	0.37	0.57	3.59	30	<.001
T1 Practice (Endline-Baseline)	0.66	0.62	5.93	30	<.001
T2 Knowledge (Endline-Baseline)	0.72	0.67	5.96	30	<.001
T2 Attitude (Endline-Baseline)	0.49	0.48	5.74	30	<.001
T2 Practice (Endline-Baseline)	0.68	0.53	7.17	30	<.001
T3 Knowledge (Endline-Baseline)	1.05	0.64	9.03	30	<.001
T3 Attitude (Endline-Baseline)	0.53	0.59	5.01	30	<.001
T3 Practice (Endline-Baseline)	0.99	1.02	5.43	30	<.001

Note. T1 = Multiple Means of Representation; T2 = Multiple Means of Engagement; T3 = Multiple Means of Expression. All tests are two-tailed (p-<.05).

Key Findings

- **UDL Principle-T1 (Representation):** Knowledge (+0.78) and Practice (+0.66) improved markedly; Attitude increased moderately (+0.37).
- **UDL Principle-T2 (Engagement):** Knowledge (+0.72) and Practice (+0.68) showed substantial gains; Attitude improved by +0.49.
- **UDL Principle-T3 (Expression):** Knowledge (+1.05) and Practice (+0.99) recorded the largest improvements; Attitude rose by +0.53.
- All improvements were statistically significant ($p < .001$).

Impression

The intervention had a robust and consistent positive impact on teachers' KAP across all UDL principles, with particularly strong gains in Knowledge and Practice domains. This suggests enhanced teacher readiness and capability to implement UDL-aligned strategies effectively.

3.6.2.2 Effect Size and Magnitude of Change

To determine the magnitude and practical significance of changes observed between baseline and endline, outputs of paired-samples *t*-tests and its corresponding effect sizes (Cohen's *d*) were calculated for overall KAP domains (Table 3.16).

The analysis revealed statistically significant improvements across all three domains from baseline to endline ($p < .001$). The estimated effect sizes were large for Knowledge ($d = 1.50$), Attitude ($d = 1.08$), and Practice ($d = 1.53$), indicating substantial practical significance in addition to statistical significance.

Table 3.16 *Overall Effect Sizes and Magnitude of Change in Teachers' KAP Scores from Baseline to Endline (N = 31)*

Dataset	Mean Diff.	*SD*	*t-test*	*df*	*p-value*	*Cohen's 'd ' value*
Knowledge (Endline-Baseline)	.84	.56	8.367	30	<.001	1.50
Attitude (Endline-Baseline)	.43	.40	5.952	30	<.001	1.08
Practice (Endline-Baseline)	.78	.51	8.599	30	<.001	1.53

Key Findings

- **Knowledge** demonstrated a large improvement (ΔM = 0.84; *d* = 1.50).
- **Attitude** showed a statistically significant increase with a large effect size (ΔM = 0.43; *d* = 1.08).
- **Practice** recorded the largest magnitude of change (ΔM = 0.78; *d* = 1.53).
- All observed changes were statistically significant at the .05 level ($p < .001$).

Impression

The large effect sizes across KAP suggest that the intervention had a strong and meaningful impact on teachers' professional competencies, with particularly pronounced effects on knowledge acquisition and instructional practice. These findings highlight the effectiveness of the UDL-aligned ICT-based OER module in strengthening inclusive pedagogical practices.

3.7 Project Impacts on Teachers' Inclusive Pedagogical Practices

The project resulted in statistically significant and educationally meaningful improvements in teachers' professional competencies related to inclusive pedagogy. Across all Universal Design for Learning (UDL) principles, teachers demonstrated consistent gains in Knowledge, Attitude, and Practice following the intervention.

The most substantial impacts were observed in the Knowledge and Practice domains, indicating strengthened teacher capacity to design and implement UDL-aligned instructional and assessment strategies. Teachers showed marked improvements in applying multiple means of representation, engagement, and expression within lesson planning and classroom practice, particularly through the effective use of ICT tools.

Attitudinal outcomes remained positive throughout the project, with modest but consistent increases observed at endline. This suggests sustained teacher commitment to inclusive, learner-centred approaches and increased confidence in adopting flexible teaching strategies.

The largest gains were associated with the principle of Multiple Means of Expression, reflecting enhanced teacher capability in offering varied assessment formats, supporting

student choice, and providing multimodal feedback. These changes indicate a shift towards more flexible, equitable, and inclusive assessment practices.

Effect size analyses confirmed that the observed improvements were large across all domains, demonstrating that the impacts were not only statistically significant but also practically meaningful. Collectively, these findings indicate improved teacher readiness to implement inclusive pedagogical practices at scale, with potential for sustained impact on classroom instruction and learner participation.

Chapter 4: Qualitative Findings

4.1 Overview

In contemporary education, the integration of Information and Communication Technology (ICT) has become a central focus for enhancing teaching and learning, particularly in ways that support inclusivity and learner engagement. In Bhutan, where schools differ widely in terms of digital infrastructure and access, understanding how teachers employ ICT in classroom settings is critical for designing meaningful professional development and educational policies.

The thematic analysis of the baseline and endline interview data generated seven themes reflecting teachers' knowledge, attitudes, and practices (KAP) in relation to the integration of educational technologies aligned with the principles of Universal Design for Learning (UDL). The themes are:

1. Teachers' ICT Practices in Classroom Teaching
2. Awareness of Learner Diversity and Inclusion
3. ICT for Multiple Means of Representation
4. ICT for Multiple Means of Action and Expression
5. ICT for Multiple Means of Engagement
6. Accessibility and Equity in ICT Use
7. Perceived Role of ICT in Reducing Learning Barriers

The themes serve as the analytical structure for exploring changes in teachers' KAP across the baseline and endline interviews. The detailed findings are presented in the following sections.

4.2 Theme 1: Teachers' ICT Practices in Classroom Teaching

This theme captured teachers' reported use of ICT before and after the intervention, focusing on the types of ICT tools employed, how these tools were embedded within lessons, and the digital learning materials used in classroom teaching.

At baseline, teachers' use of ICT was largely limited to a few tools, primarily PowerPoint (PPT) presentations, video clips, projectors, and subject-specific software

such as GeoGebra. ICT was mostly used to support teacher explanations and visualise concepts that were difficult to convey through the chalkboard alone. As one teacher (2517) described, "I regularly use ICT tools such as GeoGebra, a projector, my laptop, PowerPoint presentations, and YouTube videos in my mathematics classes". Similarly, teacher (2521) noted, "I mostly use videos and PowerPoint presentation in my classes."

Typically, teachers integrated ICT tools after the core lesson had been explained, mainly to enhance understanding as shared by teacher (2517), "Once students have some understanding, I introduce ICT tools to help them visualise the concept more clearly and see its practical application. GeoGebra, in particular, helps me explain concepts that are difficult to represent accurately on the board." A similar approach was reported in science classrooms, where videos were used to support the explanation of abstract or unobservable concepts:

> … especially in chemistry, there are many concepts where we cannot actually see with our eyes, but they are actually designed and in a way that animated form. So, in order to teach those, structure of those chemical compounds, showing video for students, so that they can get some concept from that video. (2521)

Student use of ICT at baseline was generally limited with most activities remaining teacher-directed. While some teachers provided students to explore ICT tools or prepare presentations, these opportunities were limited. For instance, one teacher said, "I have given some questions as well, so that they can explore more and come up with some interactive presentation and here they can explore more and they can be self-learners" (2511). However, the extent of student-led ICT use was constrained by contextual factors, including limited access to ICT facilities and equipment. As one teacher noted, "Although I know other tools, the ICT lab is most of the time occupied, so I cannot use it" (2521).

By the endline, teachers reported a noticeable expansion in both the range of ICT tools used and the purposes they served in classroom teaching. In addition to PPT and video clips, teachers described actively integrating platforms such as Canva for creating visually appealing and structured slides, GeoGebra for supporting mathematical understanding, and simulations for science topics. Several teachers attributed these changes to increased confidence and awareness developed through the ICT-focused professional intervention. For instance, teacher (2517) explained,

> After completing the ICT module, I am now using more ICT tools than before. I regularly use PowerPoint presentations, and I prepare them using Canva, which I was not aware of earlier. I also use GeoGebra in mathematics classes to support concept understanding.

Another teacher (2519) highlighted the practical value of these tools in lesson delivery: "I use GeoGebra to demonstrate graphical changes in one period instead of spending an entire week explaining the same concept manually. I also use Canva-based slides to present mathematical concepts in a structured way." Some teachers also reported experimenting with AI tools such as ChatGPT to support research-based learning activities and lesson preparation (2511, 2521). The data further indicated a shift towards greater student involvement in the creation and use of digital learning materials. Teachers reported assigning tasks such as preparing presentations, selecting digital resources, and presenting learning outcomes to peers using ICT tools (2508, 2521, 2530). In some cases, students were allowed to choose platforms they were familiar with, including Canva and PPT, to demonstrate their understanding. Teachers also described organising peer-support groupings to facilitate learning:

> I make sure that those one or two students who are less familiar with ICT are grouped with those who have more experience, so they can learn from each other. Before leaving the class, I check that the student has understood and can present their learning in the next lesson. (2530)

Another teacher (2508) commented on students' growing confidence in using presentation tools: "Some students are very good at designing lessons using PowerPoint. They find different sources and make the lesson very interesting."

Despite these developments, ICT practices at endline were not uniform across all participants. Some teachers continued to rely primarily on teacher-led presentations due to constraints such as limited access to devices, time pressures, and school policies restricting students' use of mobile phones (2511, 2519). Nevertheless, most teachers reported that ICT integration supported clearer explanation of concepts and enabled more flexible approaches to classroom teaching.

Overall, teachers' ICT practices shifted from limited, teacher-centred use of familiar tools at baseline to more varied and purposeful integration at endline. While structural constraints persisted, teachers demonstrated increased confidence and pedagogical flexibility in embedding ICT to support classroom teaching.

4.3 Theme 2: Awareness of Learner Diversity and Inclusion

This theme captured teachers' recognition of learner diversity before and after the intervention, focusing on awareness of students' different learning needs, interests, and backgrounds, and how these differences influence classroom practices.

At baseline, teachers demonstrated a clear awareness of learner diversity within their classrooms, particularly in relation to differences in students' learning pace, levels of understanding, and access to learning resources. Teachers frequently acknowledged that not all students responded to instruction in the same way and that some learners required additional support or alternative forms of explanation to grasp key concepts. For example, teacher (2508) noted that when using videos, they deliberately paused and re-explained content "for the one who are low achievers so that they can understand", indicating sensitivity to differences in learners' comprehension.

Awareness of inequitable access to ICT was also evident in teachers' accounts. Several teachers recognised that students' opportunities to engage with ICT tools varied depending on whether they were day students or boarders, and on the availability of devices at home. A teacher (2508) observed that "for boarding students, it's quite difficult… most of them are not getting that one," whereas day students were more likely to have access to mobile phones and internet connectivity. Another teacher highlighted the need to adapt communication methods accordingly, explaining that learning materials were shared digitally with students who had access, while printed copies were provided for those who did not (2530).

In addition, two teachers expressed awareness of gender-related differences in students' engagement with ICT-based activities. While a few teachers reported equal access for boys and girls, others perceived boys to be generally more confident in exploring digital tools. One teacher noted that "boys often dominate ICT-based activities," prompting conscious attention to participation patterns within the classroom (2517). Another

teacher (2530) reflected that the boys tended to explore ICT tools and applications independently, whereas girls relied more on what was introduced during lessons.

At endline, teachers demonstrated similar awareness of learner diversity as they did in the baseline. However, unlike at baseline, teachers showed greater intention in planning ICT-supported lessons to accommodate varied learning needs. They acknowledged the varying abilities of learners, and described designing lessons with these differences in mind. For instance, teacher (2517) said, "In my classroom, there are diverse learners like slow learners, average learners, and high achievers. I design my lessons in a way that the introduction is common for all students but vary activities according to their learning levels". This reflects a shift from general awareness at baseline to more deliberate consideration of learner variability at endline.

Teachers also expressed increased sensitivity to issues of access and participation. Several stressed that not all students had equal access to ICT tools outside school and described strategies to mitigate this within classrooms. One teacher explained, "Boarders are getting help from day scholars… sometimes they are using ICT labs and Library also equipped with the internet facilities" (2508). Others described deliberately grouping students with differing ICT skills so that less confident learners could be supported by peers: "I put them in the group of those students who have more knowledge in ICT usage. So, they teach them" (2530).

Awareness of social and gender-related considerations was evident as well. Teachers noted that both boys and girls could participate equally in ICT-supported activities when opportunities were provided, and they adopted strategies such as grouping students to ensure equitable participation. One teacher reflected, "I sometimes ask the day scholar students to bring their phones to be used in the class. And for that I always divide students in groups so that they can participate equally in the work" (2511).

Overall, teachers' awareness of learner diversity evolved from general recognition of differences at baseline to more deliberate and intentional consideration of learner variability at endline. Teachers increasingly planned ICT-supported lessons with attention to differences in ability, confidence, access, and participation.

4.4 Theme 3: ICT for Multiple Means of Representation (UDL Principle 1)

This theme explored how teachers use ICT to present content in varied formats to accommodate diverse learning needs and enhance students' understanding.

At baseline, teachers primarily relied on PPT slides, videos, and occasionally GeoGebra to present content. While they recognised the potential of visual and interactive tools, their use was often constrained by limited access to projectors and ICT labs, irregular internet connectivity, and their own limited familiarity with advanced ICT platforms. A teacher (2521) explained, "I mostly use videos and PowerPoint presentation in my classes. Although I know other tools, the ICT lab is most of the time occupied, so I cannot use it". Another noted attempts to support different learning styles while working within these constraints: "I combine board explanations, PowerPoint slides, GeoGebra demonstrations, and YouTube videos so that students with different learning styles can understand the lesson. I carefully select videos that use simple language and clear explanations to ensure that weaker students are not left behind" (2517).

Teachers reported that ICT artefacts were largely teacher-created, with minimal student involvement in generating content. Some opportunities for students to demonstrate learning using ICT, such as preparing presentations, were mentioned, but these practices were infrequent and not systematically integrated. Overall, while teachers were aware of diverse learning needs and the value of multiple representations, practical constraints and limited confidence with ICT tools restricted the effective implementation of Multiple Means of representation in their lessons.

Following the intervention, teachers reported an increased use of ICT tools to represent content in ways that make abstract concepts more tangible and accessible to all students. They regularly employed Canva, GeoGebra, interactive slides, simulations, and videos to support understanding. One teacher (2517) explained, "After completing the ICT module, I am now using more ICT tools than before. … I prepare them using Canva, which I was not aware of earlier. I also use GeoGebra in mathematics classes to support concept understanding."

Teachers highlighted that ICT allowed them to adapt content presentation for diverse learners, ensuring clarity and accessibility. For instance, teacher (2517) described, "I design my lessons in a way that the introduction is common for all students but vary activities according to their learning levels. I use ICT tools such as Canva presentations and GeoGebra to present content visually and clearly."

The use of simulations, interactive slides, and video demonstrations also helped students visualise concepts that are otherwise difficult to grasp through traditional teaching methods. One teacher reported, "There are some simulations online where they will learn about ionic bond. I also let my students to watch the video and then they attempt a quiz." (2521). Teachers observed that these ICT tools not only made lessons more engaging but also helped students internalise concepts more effectively. For example, teacher (2508) shared that some students make slides or videos to present what they've learned helping them to internalise the content while practicing ICT skills.

Despite these improvements, teachers acknowledged constraints in resources, including limited computers and internet connectivity, which sometimes restricted the full use of ICT for representation.

Overall, the intervention strengthened teachers' capacity to use ICT for multiple means of representation, moving from largely linear, teacher-created resources to more diverse, interactive, and student-responsive formats. Despite resource constraints, teachers demonstrated greater intentionality in designing accessible representations aligned with UDL Principle 1.

4.5 Theme 4: ICT for Multiple Means of Action and Expression (UDL Principle 2)

This theme explored how teachers provided students with opportunities to express their learning using ICT, including the range of tools available and the degree of student agency in creating ICT-based artefacts.

At baseline, most teachers relied primarily on written work, oral responses, and traditional assessments to evaluate student learning. For example, teacher (2519) reported assessing students mainly through tests and notebook work, with little

emphasis on ICT-based outputs. Although ICT was frequently used for content delivery such as PPT presentations and videos, students were seldom expected to independently create digital artefacts as a routine part of learning.

That said, some teachers (2517, 2508) described emerging practices aligned with UDL Principle 2. A few provided opportunities for students to prepare group presentations using PPT, particularly in higher classes, and rotated these opportunities so that students could participate over time. Others (2521, 2511) allowed students to choose between presenting their understanding using PPT, chart paper, diagrams, or verbal explanations, thereby offering limited flexibility in modes of expression. However, these activities were often occasional rather than systematically embedded within lesson design.

Importantly, student agency in using ICT remained constrained. Teachers typically set the format, content, and structure of presentations, and some deliberately restricted the use of video-based submissions to prevent superficial engagement with the task (2521). As a result, while baseline practices demonstrated early awareness of alternative modes of expression, opportunities for students to independently select tools, create diverse digital artefacts, or express learning through ICT in sustained ways were limited.

At endline, teachers reported notable changes in how ICT was used to support multiple means of student action and expression. Teachers described providing greater flexibility in how students demonstrated their learning, with ICT increasingly embedded into classroom tasks rather than used solely for teacher-led instruction. Several teachers reported first modelling concepts using ICT and then allowing students to work independently or collaboratively using the same tools. For example, teacher (2517) explained, “First I demonstrate the concept using ICT and then ask students to work independently or in pairs using the same tools”. Students were also encouraged to prepare presentations, explore digital resources, and complete assignments using platforms such as Canva, Google Slides, simulations, and videos, both during lessons and through extended access to ICT labs (2517, 2508).

A key development at endline was the increased provision of choice in modes of expression. Teachers described allowing students to decide how they wished to represent their understanding, including through models, videos, PowerPoint or Canva-based presentations, and chart papers. One teacher noted that during a lesson on green

chemistry, students were permitted to select their preferred format, resulting in varied representations of learning, including digital presentations created using Canva (2521). Such flexibility reflected a growing awareness of the need to accommodate diverse strengths and preferences in student expression.

Teachers also highlighted the role of peer collaboration in supporting ICT-based expression, particularly for students with limited prior experience. Students with stronger ICT skills were intentionally grouped with peers who required additional support, enabling knowledge-sharing and guided participation (2530). In contexts where access to personal devices was uneven, teachers described leveraging ICT labs, shared mobile phones, and school-based internet facilities to ensure that all students could participate in ICT-supported tasks (2508, 2517).

Despite these improvements, teachers acknowledged that challenges remained. Some students required additional scaffolding to adapt to ICT-based tasks, which increased demands on instructional time (2521). Constraints related to device availability, internet connectivity, and school policies continued to influence the extent to which ICT-based expression could be implemented consistently. Nevertheless, endline findings suggest a clear shift towards more inclusive, flexible, and student-responsive approaches to action and expression aligned with UDL Principle 2.

Overall, teachers progressed from predominantly traditional and teacher-directed assessment practices towards more flexible, ICT-supported opportunities for student action and expression. Endline practices reflected increased student choice, collaboration, and agency, aligning more closely with UDL Principle 2.

4.6 Theme 5: ICT for Student Engagement and Motivation (UDL Principle 3)

This theme focused on how teachers use ICT to engage and motivate students, particularly during low-energy periods or with learners who may be disengaged.

At baseline, teachers recognised ICT as a useful tool for motivating students but described its use as situational rather than systematic. ICT was most commonly introduced when students appeared tired, disengaged, or when conventional teaching approaches were perceived as less effective. For example, teacher (2517) explained that short videos were

used to refresh students' attention, particularly during hot weather or long lessons, noting that this helped "reduce monotony and increase students' interest in the lesson". Similarly, teacher (2530) reported turning to videos or movies when they felt their teaching was "not getting effective for the students," as an alternative way to help learners grasp the lesson.

Teachers also highlighted that ICT-supported engagement often depended on time availability and curricular demands. A mathematics teacher (2519) pointed out that the syllabus was "very vast," leaving little time to incorporate ICT-based engagement strategies, resulting in a continued focus on writing and board work. As a result, ICT use for engagement was frequently limited to PowerPoint presentations or occasional video clips, rather than interactive or student-led digital activities.

Despite these constraints, several teachers described ICT as enhancing students' interest and enjoyment, particularly when learners were given opportunities to participate actively. Some encouraged group presentations using PPT, noting that students "enjoyed" preparing and presenting their work with ICT tools (2508). Others allowed students to choose between preparing presentations digitally or using chart papers, which helped sustain motivation by giving learners a sense of autonomy and choice (2508, 2521). In some cases, teachers responded directly to student feedback by sourcing or creating video lessons to improve engagement and understanding, indicating an emerging responsiveness to learners' motivational needs (2530).

At endline, teachers reported a marked shift in how ICT was used to promote student engagement and motivation. ICT was no longer viewed merely as a visual supplement to teaching but increasingly functioned as a means to actively involve students in learning. Teachers described using a wider range of tools such as Canva-based presentations, GeoGebra, simulations, and online videos, to stimulate curiosity, sustain attention, and encourage participation across diverse learner groups.

Teachers highlighted that ICT-supported engagement was particularly effective when students struggled with traditional instruction. Teacher (2517) explained, "When students do not clearly understand concepts through chalk-and-board teaching, I use ICT tools such as GeoGebra and YouTube videos. These tools help students visualise mathematical concepts… and students get interested". Others noted that the use of

visually rich and well-structured digital materials helped maintain students' attention and motivation, especially for abstract or conceptually demanding topics. The incorporation of images, animations, and simulations was frequently described as making lessons "more engaging and interesting" for students (2508, 2511).

A notable development at endline was the increased emphasis on student autonomy and choice as a motivational strategy. Several teachers reported allowing students to decide how they wished to demonstrate their understanding using ICT. As one teacher shared, "I allowed them to come up with model or either with their own video or with PPT presentation or maybe through chart paper" (2521). This flexibility was seen as motivating students by aligning learning tasks with their interests and strengths. Teachers also observed that such approaches encouraged participation from students who were previously less confident, particularly when learning activities were structured through group work and peer support (2508, 2530).

Despite these positive changes, engagement through ICT remained influenced by contextual constraints. Limited access to personal devices and school policies restricting mobile phone use sometimes prevented teachers from using interactive tools such as live quizzes. One teacher reflected, "I planned to use Slido, but it wasn't possible since children were not having mobile phones in the classroom, so I went with Canva" (2530). In response, teachers adapted by embedding videos, visuals, and discussion prompts into presentations, or by pairing students with varying levels of ICT familiarity to sustain engagement.

Overall, ICT use for engagement shifted from situational and reactive practices at baseline to more intentional and pedagogically grounded approaches at endline. Increased use of interactive tools, visual resources, and student choice supported sustained motivation in line with UDL Principle 3, despite ongoing contextual constraints.

4.7 Theme 6: Accessibility and Equity in ICT Use

This theme examined how teachers ensure that ICT tools are accessible to all students, strategies for mitigating the digital divide, and how equitable participation is promoted within classroom learning.

Even at baseline, teachers demonstrated a strong awareness of disparities in students' access to ICT, both within school and at home. Overcrowded ICT labs, insufficient projectors, unreliable internet connectivity, and frequent power cuts, was widely reported. Teacher (2519) noted, "We have limited projectors and we cannot book the ICT rooms also; it is packed always". These constraints meant that many ICT-based activities were irregular and dependent on availability rather than pedagogical intent. Differences between day scholars and boarders were also highlighted, with boarders facing more restricted access to personal devices and internet connectivity outside class time (2508).

Despite these limitations, teachers described multiple strategies to promote equitable access. These included rotating student access to limited devices, pairing students to share computers, and organising supervised lab access during free periods or weekends. One teacher (2517) explained, "Due to the limited number of computers, students often have to share devices… I rotate access and allow interested students to use my laptop or library computers during free time". Others reported printing learning materials or providing notes to students who could not access digital resources, ensuring that learning was not dependent solely on technology (2530). Several teachers went beyond institutional provisions to address equity concerns. In some cases, teachers supported students financially by recharging data packages or providing printed copies at their own expense: "We pay from our own pocket… I don't mind doing that as long as the lesson learning is being completed" (2530). Teachers also described adapting ICT materials to students' language levels and learning needs, selecting simple videos and re-explaining content to ensure inclusion. While some teachers perceived gender differences in ICT engagement, observing that boys tended to explore ICT tools more independently than girls, efforts such as mixed-gender grouping and peer support were used to encourage broader participation (2517, 2530).

Teachers also reported more deliberate efforts to address accessibility and equity in ICT-supported learning. To mitigate disparities in access to devices and connectivity, teachers facilitated shared use of available technologies through school ICT labs, libraries, and peer-supported arrangements. One teacher explained that "boarders are getting help from day scholars" and that students without personal access could use "ICT labs and library also equipped with the internet facilities" during school hours and free periods

(2508). Access beyond the classroom was also provided by creating Telegram class forums, allowing students to access learning materials and participate in tasks when school-based resources were unavailable (2530).

Equity was further supported through intentional grouping strategies and flexible arrangements. Teachers paired students with differing levels of ICT access and competence so that those with stronger skills could support peers who were less confident or newly transferred from other schools (2530). In some cases, teachers stayed after school, booked ICT labs during free periods, or provided one-to-one guidance to ensure that boarding students and those from remote areas were not excluded from ICT-based activities (2521, 2530). When digital access was not possible, teachers also relied on alternative approaches such as verbal responses, printed notes, and shared demonstrations to maintain inclusive participation (2508, 2511).

In terms of gender and social participation, most teachers reported no noticeable differences in ICT engagement between male and female students. As one teacher noted, "both the genders are equally equipped with such knowledge of using ICT" and were observed to participate equally when opportunities were provided (2508). However, teachers acknowledged that access remained uneven for a small number of students due to parental restrictions, limited availability of devices, or school-level policies on mobile phone use. One teacher explained that "parents don't allow students to use phones after school", requiring teachers to "adjust accordingly" by finding alternative access routes within the school (2530). Despite these ongoing constraints, teachers demonstrated increased responsiveness and agency in addressing equity concerns, reflecting a more intentional approach to inclusive ICT use.

Overall, teachers demonstrated a more proactive and systematic approach to addressing accessibility and equity by endline. Through shared access, peer support, and flexible arrangements, teachers mitigated aspects of the digital divide and promoted more inclusive participation in ICT-supported learning.

4.8 Theme 7: Perceived Role of ICT in Reducing Learning Barriers

The theme explored teachers' beliefs about how ICT tools can mitigate learning barriers, including cognitive, linguistic, and social obstacles, and their perceptions of students' access to and use of ICT resources.

At baseline, teachers reported that traditional teaching methods posed challenges to students with limited prior knowledge, slower processing speeds, or lower confidence. Teacher (2511) reflected, "Last year, most of the time I used to teach through board, using white board and all. Some of my students suggested using interactive lessons so that they can get more knowledge".

Teachers recognised that ICT had the potential to support learning, especially for students who struggled with traditional methods. Tools such as PhotoMath helped students understand mathematical steps (2519), while videos supported comprehension of abstract concepts like chemical structures and ecosystems (2521, 2508). Teachers perceived ICT as a means to create more equitable opportunities for participation, particularly for shy, introverted, or less confident students (2517, 2530).

At endline, teachers reported a significant shift in perceptions. ICT was increasingly seen as an effective way to reduce learning barriers by making lessons interactive, visual, and accessible to all students. Teacher (2517) explained, "Earlier, teaching was teacher-centred and language-dependent. Now, with ICT, learning has become visual, interactive, and engaging through animations, images, and simulations, which helps students understand concepts better without relying on language proficiency".

Teachers highlighted that ICT enhanced student agency and confidence, allowing learners to participate in ways suited to their abilities and learning needs. They viewed ICT as supporting understanding, engagement, and participation for diverse learners. For instance, teacher (2521) said, "I used ChatGPT for students when they were doing research projects. It helped guide them in probing questions and getting correct answers".

Overall, teachers' perceptions of ICT shifted from viewing it as a supplementary aid to recognising it as a key enabler in reducing cognitive, linguistic, and participation-related learning barriers. Endline findings indicate increased confidence in ICT as a tool for supporting inclusive and learner-responsive teaching.

4.9 Chapter summary

This qualitative study examined Bhutanese teachers' integration of ICT for inclusive teaching through the lens of Universal Design for Learning (UDL), drawing on baseline and endline interview data. At baseline, ICT use was predominantly teacher-centred and limited to familiar tools such as PowerPoint, videos, projectors, and subject-specific software like GeoGebra. These tools were mainly used to support content delivery and visualisation, with limited opportunities for student agency or differentiated learning pathways. Although teachers demonstrated awareness of learner diversity, motivational differences, and access-related constraints, inclusive ICT practices were largely ad hoc and shaped by structural limitations such as inadequate infrastructure, uneven access to devices, time constraints, and institutional policies. As a result, the provision of multiple means of representation, action and expression, and engagement was present but not systematically embedded in pedagogical design.

Following the professional intervention, teachers reported a clear shift towards more intentional and inclusive ICT integration aligned with the three UDL principles. ICT tools were used more strategically to present content in varied formats, support student choice in demonstrating learning, and enhance engagement through interactive and collaborative activities. Teachers expanded their digital selection to include tools such as Canva, simulations, interactive platforms, and, in some cases, AI-supported applications, alongside increased use of peer support, flexible grouping, and scaffolded tasks. While persistent challenges related to access, infrastructure, and policy remained, teachers adopted adaptive strategies to mitigate these constraints, including shared device use and blended online–offline approaches. By endline, ICT was widely perceived as an enabler of inclusive learning, supporting conceptual understanding, reducing language dependence, and increasing student participation and agency.

Chapter 5: Discussion, Conclusions and Implications

5.1 Discussion of Key Findings

This chapter synthesizes the quantitative and qualitative findings to provide an integrated interpretation of the Impact Scaling CL4STEM project's outcomes in Bhutan. The mixed-methods evidence indicates that the intervention contributed to measurable improvements in teachers' knowledge, attitudes, and practices (KAP) related to the use of ICT-enabled, UDL-aligned Open Educational Resources (OERs), while also shaping teachers' instructional thinking and classroom-level implementation (Jackson & Harper, 2005).

The quantitative findings presented in Chapter 3 demonstrate consistent gains across KAP domains, with the strongest improvements observed in knowledge and self-reported practices. These results suggest that the structured professional development (PD) support and exposure to UDL-aligned OERs enhanced teachers' conceptual understanding of inclusive, learner-centred pedagogies and their ability to translate this understanding into instructional planning and classroom strategies. Such shifts are consistent with evidence that UDL-oriented professional development can influence teacher knowledge and practice by reframing UDL as an adaptable pedagogical approach rather than a static checklist of strategies (Lambert et al., 2023; Meyer et al., 2014).

Attitudinal scores were positive at baseline and showed modest increases at endline, indicating that while teachers were already favourably disposed towards inclusive practices, the intervention reinforced their confidence and perceived feasibility of implementation. Research suggests that teachers' beliefs and self-efficacy with respect to inclusive pedagogy grow through sustained engagement with UDL principles and reflective practice, supporting deeper conceptualisation of instructional flexibility (Lambert et al., 2023).

The qualitative findings presented in Chapter 4 provide explanatory depth to these patterns. Teachers' reflections highlight increased awareness of learner variability, more

deliberate lesson design, and greater use of multiple representations, engagement strategies, and assessment approaches. Qualitative evidence illustrates how teachers adapted OER materials to local classroom contexts, thereby strengthening relevance and ownership. These findings align with broader research indicating that meaningful UDL implementation requires adaptation to context, collaborative reflection, and practical support for planning and delivery (Almeqdad at al., 2023; Catama, 2025; Rose at al., 2017).

Teachers' integration of ICT evolved notably over the intervention. While ICT use was initially teacher-directed, limited to PowerPoint, videos, projectors, and subject-specific software, endline findings demonstrated more deliberate and flexible application. Teachers employed a wider range of ICT tools, fostered student choice and agency in learning activities, and implemented strategies to promote equity and accessibility. ICT was increasingly perceived as an enabler of inclusive learning, supporting conceptual understanding, motivation, participation, and the reduction of learning barriers (Rao et al., 2014; Smith & Okolo, 2022). Together, the findings suggest that the observed quantitative changes were not merely procedural but were underpinned by meaningful shifts in pedagogical reasoning and practice.

5.2 Conclusions

Overall, the Impact Scaling CL4STEM project demonstrates that a practice-based, ICT-supported PD model centred on UDL-aligned OERs can strengthen secondary STEAM teachers' readiness to implement inclusive and learner-centred instruction in the Bhutanese context. The convergence of quantitative improvements in KAP scores and qualitative evidence of classroom application provides credible evidence of the project's effectiveness during the impact scaling phase.

The findings indicate that scalable PD models combining structured learning modules, contextualised resources, and reflective practice can support sustained changes in teaching practice. While the study does not claim causal attribution beyond the scope of the design, the consistency of findings across data sources suggests that the intervention made a meaningful contribution to improving teachers' professional capacity.

5.3 Implications for Policy, Practice, and Scaling

The findings have several implications for education systems and development partners:

- **Policy:** The results support the integration of UDL principles and OER-based approaches within national teacher professional development frameworks, particularly regarding inclusive and ICT-supported pedagogy.
- **Practice:** School leaders and teacher educators may leverage modular, practice-oriented PD models to promote learner-centred instructional design and assessment strategies across STEAM subjects.
- **Scaling and Sustainability:** The adaptability of OERs and the positive teacher response indicate strong potential for scaling the model to additional schools and districts, provided that continued institutional support and alignment with existing systems are ensured.

5.4 Limitations and Future Directions

This study relied on self-reported measures of practice and was conducted in a single school, focusing specifically on STEAM subjects within a defined project timeframe. Teacher practices, student profiles, and access to ICT tools can vary widely across schools. Nevertheless, as the first study of its kind in Bhutanese STEAM subjects, it provides valuable baseline evidence. Future research could strengthen findings through classroom observations, student-level outcomes, and scaling the intervention to a wider range of schools in Bhutan. Incorporating larger and more diverse samples, as well as comparative designs, would further enhance generalisability and sustainability of practice changes.

5.5 Key Takeaways

- **Demonstrated Impact:** The mixed-methods evidence shows consistent improvements in teachers' knowledge and instructional practices related to inclusive, UDL-aligned STEAM teaching, supported by both quantitative gains and qualitative classroom-level insights.

- **Effective PD Model:** A practice-based, ICT-supported professional development approach using UDL-aligned OERs is effective in strengthening teacher capacity within a relatively short implementation period.
- **Scalability and Adaptability:** The use of open and modular resources enables contextual adaptation while maintaining core pedagogical principles, making the model suitable for scaling across diverse school settings.
- **Value for Investment:** The intervention leverages existing systems and digital resources, offering a cost-effective strategy for enhancing inclusive teaching practices at scale.
- **Policy Relevance:** Findings provide actionable evidence to inform national and regional teacher professional development policies focused on inclusion, digital pedagogy, and learner-centred education.
- **Future Learning Potential:** The project establishes a strong foundation for further learning through longitudinal tracking, classroom observation, and linkage to student outcomes.

In conclusion, the Impact Scaling CL4STEM project provides evidence that targeted, inclusive, and technology-enabled professional development can strengthen teachers' capacity to respond to learner diversity in secondary STEAM education. The lessons generated through this study offer valuable insights for policymakers, practitioners, and development partners seeking to scale effective and contextually responsive teacher professional development initiatives.

References

Almeqdad, K., Al-Ammary, J., & Al-Kabi, M. (2023). Integrating Universal Design for Learning in classroom instruction: Enhancing teacher competence and inclusivity. *International Journal of Research in Education, 10*(2), 45–64. https://journals.acspublisher.com/index.php/ijrse/article/view/21564

Bodnar, O., & Zhang, Y. (2024). Traditional and innovative models of managing teachers' professional development in management theory. *Image of the Modern Pedagogue*, (2 (215)), 118-123.

Catama, S. (2025). Implementing Universal Design for Learning in secondary classrooms: Evidence and strategies. *Journal of Inclusive Education, 15*(3), 210–225. https://doi.org/10.1080/13603116.2025.1112234

Herro, D., Hirsch, S. E., & Quigley, C. (2022). A faculty-in-residence programme: Enacting practice-based professional development in a STEAM-focused middle school. *Professional Development in Education*, *48*(4), 559-575.

Jackson, R., & Harper, H. (2005). *Teaching for diversity with Universal Design for Learning: Analysing teacher competence*. In Inclusive education and Universal Design (pp. 241–277). Springer.

Jeram, R., & Davids, N. (2020). In support of practice-based teacher professional learning. *South African Journal of Higher Education*, *34*(3), 112-127.

Lambert, R., McNiff, A., Schuck, R., Imm, K., & Zimmerman, S. (2023). *"UDL is a way of thinking": Theorizing UDL teacher knowledge, beliefs, and practices*. *Frontiers in Education, 8*, Article 1145293. https://doi.org/10.3389/feduc.2023.1145293

Meyer, A., Rose, D., & Gordon, D. (2014). *Universal Design for Learning: Theory and practice*. CAST Professional Publishing.

Osborne, J. F., Borko, H., Fishman, E., Gomez Zaccarelli, F., Berson, E., Busch, K. C., ... & Tseng, A. (2019). Impacts of a practice-based professional development program on elementary teachers' facilitation of and student engagement with scientific argumentation. *American educational research journal*, *56*(4), 1067-1112.

Rao, K., Okolo, C., & Smith, S. (2014). Using technology to support UDL: Enhancing access and engagement. *Journal of Special Education Technology, 29*(4), 1–15. https://doi.org/10.1177/016264341402900401

Rose, D., Harbour, W., Johnston, C., Daley, S., & Abarbanell, L. (2017). Universal Design for Learning in postsecondary education: Reflections and future directions. *Journal of Postsecondary Education and Disability, 30*(1), 1–14. https://doi.org/10.5555/ijpse.2017.30.1.1

Smith, S. J., & Okolo, C. M. (2022). Technology-enhanced learning in inclusive classrooms: Practical UDL applications. *Computers & Education, 185*, 104–152. https://doi.org/10.1016/j.compedu.2022.104152