

Integrating universal design for learning in mathematics education: A systematic review towards inclusive Scholarship of Teaching and Learning in South Africa

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ABSTRACT

This study presents a systematic review on the integration of Universal Design for Learning (UDL) in mathematics education to advance inclusive and equitable Scholarship of Teaching and Learning (SoTL) in South African higher education. Guided by the PRISMA 2020 framework, 126 records published between 2010 and 2025 were identified across Scopus, Web of Science, ERIC, Sabinet, and Google Scholar, with 42 studies meeting the inclusion criteria after quality appraisal. The review synthesises empirical and conceptual evidence on how UDL principles—multiple means of engagement, representation, and action/expression—are applied to promote participation, accessibility, and epistemic justice in mathematics education. Findings highlight persistent barriers, including curricular rigidity, inequitable assessment practices, resource limitations, and linguistic exclusion. However, enabling conditions such as culturally responsive pedagogy, multilingual instruction, and reflective professional communities demonstrate promise for inclusive transformation. The review concludes that integrating UDL within SoTL offers a rigorous and contextually responsive pathway to institutionalise inclusive pedagogical practices, particularly within the policy landscape shaped by the Language Policy Framework for Public Higher Education Institutions (2020). Recommendations emphasise curriculum redesign, flexible assessment, sustained professional development, and alignment of institutional policy with inclusive design principles. By situating UDL within SoTL, this study reframes inclusive mathematics education as both pedagogically robust and socially just, contributing to a more equitable higher education landscape.

Keywords: Universal Design for Learning, Inclusive Mathematics Education, Scholarship of Teaching and Learning, Systematic Review, South African Higher Education

INTRODUCTION

South Africa's higher education sector continues to grapple with entrenched inequities that restrict access, participation, and academic success—inequities that are particularly evident in mathematics education. Rooted in colonial and apartheid legacies, mathematics often functions as a “gatekeeper” to Science, Technology, Engineering, and Mathematics (STEM) pathways, shaping entry into

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PUBLICATION HISTORY - Received : 9th September, 2025 | Accepted: 11th December, 2025 | Published: 11th March, 2026.

TO CITE THIS ARTICLE –Mthethwa, Themba M., and Matshidiso M. Moleko. “Integrating Universal Design for Learning in Mathematics Education: A Systematic Review towards Inclusive Scholarship of Teaching and Learning in South Africa.” *Journal of Education and Learning Technology* 7, no.2 (2026): 64 - 84. <https://doi.org/10.38159/jelt.2026725>

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professional and economic mobility.¹ When success rates in mathematics remain unequal, the discipline reproduces social stratification rather than promoting transformation.²

Instructional practices at many South African universities still presume homogeneity in students' linguistic proficiency, prior knowledge, and cultural capital, thereby disadvantaging those from rural, low-income, or multilingual backgrounds.³ Such assumptions contradict current national policy imperatives, particularly the Language Policy Framework for Public Higher Education Institutions, which mandates the promotion of multilingualism to enhance epistemic access and equitable participation.⁴ Yet, mathematics teaching and assessment often remain monolingual, lecture-centric, and abstract—conditions that hinder inclusive learning.⁵

In response to these challenges, Universal Design for Learning (UDL) offers a flexible and evidence-based pedagogical framework for inclusion. Grounded in neuroscience and socio-constructivist theory, UDL shifts focus from “fixing the learner” to “fixing the learning environment.”⁶ It promotes multiple means of engagement, representation, and action and expression, enabling educators to design learning experiences that are accessible to all students, regardless of linguistic, cognitive, or cultural diversity. Within mathematics education, UDL aligns with growing calls for multilingual and culturally responsive pedagogies that link abstract concepts to students' lived realities.⁷

Parallel to this, the Scholarship of Teaching and Learning (SoTL) provides a reflective and evidence-based framework for improving teaching practice.⁸ SoTL encourages educators to systematically investigate their pedagogical approaches, gather evidence of student learning, and share findings within academic communities.⁹ Integrating UDL within SoTL thus allows for iterative cycles of design, reflection, and evaluation, supporting the institutionalisation of inclusive pedagogies.¹⁰ This integration also supports alignment with national transformation goals by embedding inclusivity within the professional identity of mathematics educators.

Despite global advances in UDL research, systematic and context-specific evidence on its implementation in South African higher education—particularly in mathematics—remains limited. Existing local studies often focus on primary or secondary schooling, or on support environments such as writing centres, rather than on core undergraduate mathematics curricula.¹¹ Moreover, few studies explore how UDL principles intersect with the Language Policy Framework or evaluate tangible outcomes such as performance, retention, and progression in STEM fields.¹² Consequently, the institutionalisation of UDL through SoTL in mathematics remains an emerging field with significant potential for scholarly contribution.

This study, therefore, aims to synthesise existing evidence to address this gap through a systematic review. Specifically, it seeks to determine how UDL principles are being integrated into mathematics education to foster inclusive and equitable SoTL within South African higher education. The guiding research question is: How can UDL be integrated into mathematics education to foster inclusive and equitable SoTL in South African higher education?

¹ D. Mosia, “Higher Education Inequities in Mathematics Education,” *Journal of Higher Education in Africa* 23, no. 1 (2025): 45–61.

² L. Ramrathan, “Culturally Relevant Pedagogy and Mathematics Inequality,” *Perspectives in Education* 39, no. 1 (2021): 15–29.

³ Johan Muller, *The Future of Knowledge and Curriculum* (Cape Town: HSRC Press, 2014).

⁴ Department of Higher Education and Training (DHET), *Language Policy Framework for Public Higher Education Institutions* (Pretoria: Government Printer, 2020).

⁵ K. Naidoo and D. Singh, “Assessment Practices in South African Universities,” *Journal of Education* 72 (2018): 33–52.

⁶ David H Rose and Anne Meyer, *Teaching Every Student in the Digital Age: Universal Design for Learning* (ERIC, 2002).

⁷ Anthony Essien, “Bilingual Pedagogies in Mathematics Education,” *African Journal of Research in Mathematics, Science and Technology Education* 29, no. 1 (2025): 13–30.

⁸ Keith Trigwell et al., “Scholarship of Teaching: A Model,” *Higher Education Research & Development* 19, no. 2 (2000): 155–68.

⁹ Pat Hutchings, Mary Taylor Huber, and Anthony Ciccone, *The Scholarship of Teaching and Learning Reconsidered: Institutional Integration and Impact*, vol. 21 (John Wiley & Sons, 2011).

¹⁰ T. Mthembu and R. Govender, “SoTL Integration in Mathematics Education,” *Journal of University Teaching and Learning* 17, no. 2 (2020): 11–29.

¹¹ M. Moleko and M. Maphalala, “UDL Practices in Resource-Limited Mathematics Classrooms,” *African Journal of Mathematics Education* 30, no. 1 (2025): 19–37.

¹² Department of Higher Education and Training, “Language Policy Framework for Public Higher Department Institutions” (Pretoria, 2020).

To address this overarching question, the study explores five sub-questions:

1. To what extent, and in what specific ways, are UDL principles (engagement, representation, and action/expression) applied in mathematics education in South African higher education?
2. What barriers and enabling conditions shape the adoption, adaptation, and sustainability of UDL-aligned mathematics pedagogy, including in multilingual settings mandated by the Language Policy Framework?
3. How does SoTL support the institutionalisation and scaling of UDL in mathematics, including assessment redesign and professional learning communities?
4. What evidence exists regarding the effects of UDL-informed mathematics pedagogy on student outcomes such as engagement, achievement, progression, and retention?
5. How are institutional languages and teaching-and-learning policies (post-2020) being translated into UDL-aligned pedagogical practices, and with what reported challenges and successes?

By contextualising UDL within the SoTL framework, this study contributes to the development of a socially just, epistemically inclusive, and pedagogically rigorous approach to mathematics education that supports equity, transformation, and excellence in South African higher education.

THEORETICAL FRAMEWORK

This review is grounded in two complementary theoretical frameworks: Vygotsky's socio-cultural theory and the UDL Guidelines developed by the Center for Applied Special Technology.¹³ Together, these frameworks provide an integrated foundation for analysing inclusive mathematics pedagogy through both social and neuroscientific perspectives.

Vygotsky's Socio-Cultural Theory

Vygotsky's socio-cultural theory conceptualises learning as a socially mediated process influenced by cultural, linguistic, and contextual factors.¹⁴ Central to this framework is the Zone of Proximal Development (ZPD)—the gap between what a learner can achieve independently and what they can accomplish with appropriate support or “scaffolding.”

In the context of mathematics education, scaffolding recognises that learners bring diverse cultural and linguistic resources that shape how they construct mathematical meaning. Teaching strategies that build upon these resources promote epistemic access and deepen conceptual understanding.¹⁵ Conversely, failure to embed such contextual responsiveness often perpetuates inequities in mathematical learning outcomes.¹⁶

From a socio-cultural standpoint, effective mathematics pedagogy in South Africa must therefore acknowledge multilingualism, cultural identity, and prior knowledge as central components of cognitive development. This orientation aligns with national transformation goals and the Language Policy Framework for Public Higher Education Institutions, which advocates for the integration of multilingual pedagogies to facilitate access and participation.¹⁷

Universal Design for Learning (UDL) Framework

The Universal Design for Learning framework provides an operational structure for inclusive pedagogy, drawing upon findings from neuroscience to explain how learners differ in the ways they perceive, engage with, and express knowledge.¹⁸ UDL's central principle is that variability is the norm—teaching should be designed from the outset to accommodate learner diversity rather than retrofitted for accessibility. UDL is organised around three core principles, each supported by specific guidelines:

¹³ CAST, *Universal Design for Learning Guidelines, Version 2.0.* (Wakefield, MA: CAST, 2011).

¹⁴ Lev S. Vygotsky, *Mind in Society: The Development of Higher Psychological Processes*, vol. 86 (Harvard University Press, 1978).

¹⁵ S. Mulaudzi, “Multilingual Approaches in Mathematics Classrooms,” *Educational Research for Social Change* 13, no. 2 (2024): 55–74.

¹⁶ Mosia, “Higher Education Inequities in Mathematics Education.”

¹⁷ Department of Higher Education and Training (DHET), *Language Policy Framework for Public Higher Education Institutions.*

¹⁸ CAST, *Universal Design for Learning Guidelines, Version 2.0.*

- 1) *Multiple Means of Engagement* – Cultivating motivation and persistence by connecting mathematics to learners’ interests, cultural contexts, and lived experiences. Examples include the use of locally relevant word problems, collaborative group work, and technology-mediated inquiry.¹⁹
- 2) *Multiple Means of Representation* – Presenting mathematical concepts through varied formats such as visual models, symbolic notation, graphs, and bilingual explanations to ensure accessibility for students with diverse recognition networks.²⁰
- 3) *Multiple Means of Action and Expression* – Allowing students to demonstrate their understanding through flexible assessment modes, including oral presentations, digital portfolios, and projects, thus addressing inequities in traditional exam-based evaluation.²¹

Universal Design for Learning (UDL) Framework

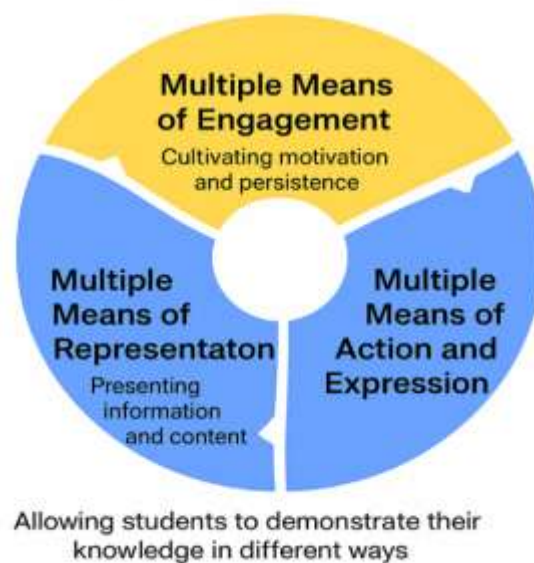


Figure 1: Revised UDL Framework – adapted from CAST 2018

The UDL Framework (Figure 1 presents these principles and guidelines in a clear, accessible format, ensuring visual clarity and alignment with updated Center for Applied Special Technology (CAST) documentation. Each principle is positioned within a cyclical model that reflects the dynamic relationship between motivation (affective networks), representation (recognition networks), and action/expression (strategic networks). This design underscores how inclusive learning environments are best achieved when all three dimensions operate in concert.

Integrating Socio-Cultural Theory and UDL

When integrated, Vygotsky’s socio-cultural theory and UDL provide a multi-dimensional framework for understanding inclusive mathematics education. Socio-cultural theory emphasises context and mediation—that learning occurs through social interaction and cultural tools—while UDL offers practical design principles for translating inclusion into instructional strategies. Together, they support a justice-oriented pedagogy that is both responsive to learners’ social contexts and structured through deliberate design. This integration is particularly relevant for South African higher education, where

¹⁹ Moleko and Maphalala, “UDL Practices in Resource-Limited Mathematics Classrooms.”

²⁰ K. Naidoo and R. Govender, “Multimodal Resources in Mathematics,” *Journal of Instructional Studies* 18, no. 3 (2020): 45–62.

²¹ Anne Bagger, “Inclusive Assessment Practices in Mathematics Education,” *International Journal of Inclusive Education* 26, no. 7 (2022): 881–99.

transformation agendas call for pedagogies that simultaneously advance equity and excellence.²² By merging socio-cultural insights with UDL's design-based inclusivity, this review positions mathematics education as a site where pedagogical innovation, equity, and epistemic justice intersect.

METHODOLOGY

Research Design

This study employed a systematic review design guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) framework.²³ A systematic review was selected for its ability to ensure a transparent, replicable, and evidence-based synthesis of research on inclusive mathematics pedagogy within higher-education contexts. Following the PRISMA 2020 protocol enabled the researchers to maintain methodological rigour, minimise selection bias, and document each stage of the review process comprehensively.

Search Strategy

The literature search was conducted across five electronic databases—Scopus, Web of Science, ERIC, Sabinet, and Google Scholar—to capture both international and South African scholarship published between 2010 and 2025. This timeframe was chosen to reflect the evolution of inclusive education and UDL scholarship alongside major national policy shifts. Boolean operators and search strings combined key terms such as:

“Universal Design for Learning” AND “mathematics education”,
“inclusive pedagogy” AND “higher education South Africa”,
“SoTL” AND “STEM education”, and
“culturally responsive mathematics” AND “UDL”.

The search was supplemented with manual screening of reference lists and grey literature—policy reports, theses, and institutional documents—to ensure completeness.

Inclusion and Exclusion Criteria

Only peer-reviewed journal articles, book chapters, and relevant policy documents explicitly addressing UDL, inclusive pedagogy, mathematics education, or SoTL within higher education were included. Studies were excluded if they:

- 1) Focused solely on primary or secondary schooling,
- 2) Were not published in English and lacked translation, or
- 3) Did not explicitly apply or discuss UDL principles in relation to mathematics pedagogy.

This refinement ensured that only conceptually and contextually relevant evidence informed the analysis.

²² Council on Higher Education (CHE), *Towards Equity in STEM Education* (Pretoria: CHE, 2023).

²³ Matthew J Page et al., “The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews,” *Bmj* 372 (2021).

PRISMA 2020 Flow Diagram for Study Selection

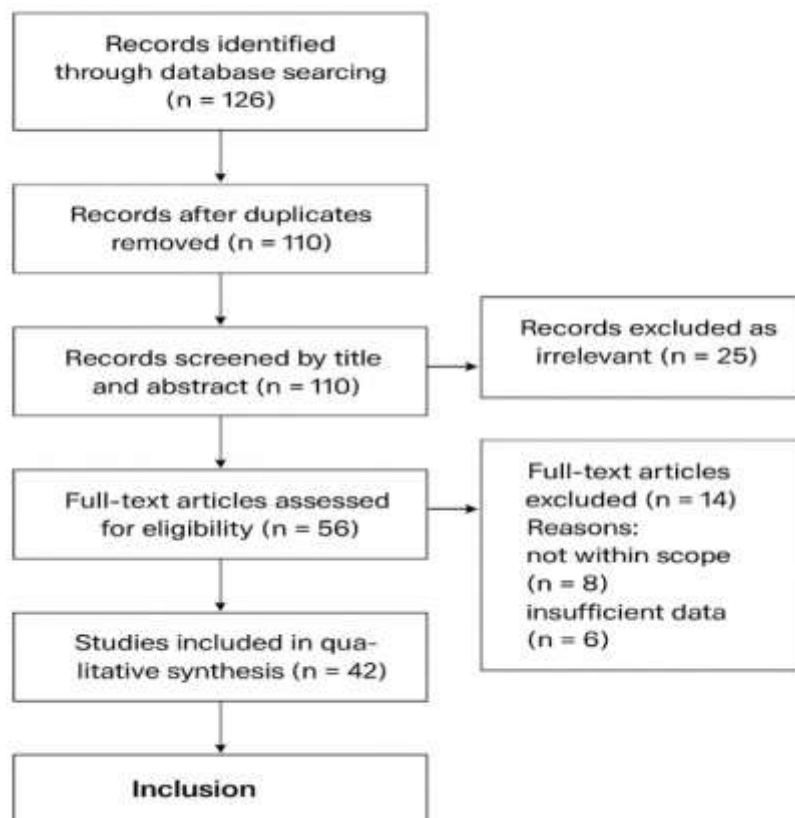


Figure 2: PRISMA flow diagram for selecting the relevant articles for this study

The identification, screening, and inclusion process followed the PRISMA 2020 stages.²⁴

- 1) Identification: 126 records were retrieved.
- 2) Deduplication: 16 duplicates removed → 110 unique records.
- 3) Screening: Titles and abstracts screened for relevance → 85 articles retained.
- 4) Eligibility: 56 full texts reviewed against inclusion criteria.
- 5) Inclusion: 42 studies met quality and relevance thresholds and were incorporated into the final synthesis.

Quality Appraisal

A formal quality-appraisal process was added to ensure that only methodologically sound studies informed the synthesis. Each article was evaluated using a modified version of the Joanna Briggs Institute (JBI) critical-appraisal checklist for qualitative and quantitative studies.²⁵ Appraisal criteria included:

²⁴ Page et al., “The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews.”

²⁵ David Gough, Sandy Oliver, and James Thomas, “An Introduction to Systematic Reviews (2nd Edition),” *Psychology Teaching Review* 23, no. 2 (2017): 95–96, <https://doi.org/10.53841/bspstr.2017.23.2.95>.

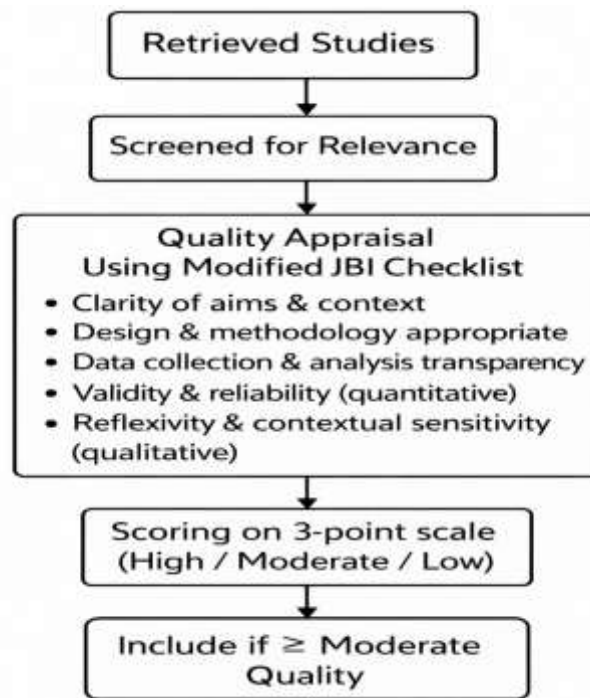


Figure 3: Quality appraisal flow using the modified JBI checklist

Each criterion was rated on a 3-point scale (high, moderate, low). Only studies rated moderate or higher were included. Where methodological limitations were noted but findings were contextually significant, justification for inclusion was recorded in an audit trail, see figure 3 above:

Data Extraction

For the 42 eligible studies, key information was systematically extracted using a literature-matrix template (*see table 1*). Extraction categories included:

- *bibliographic details (author, year, context),*
- *research focus and design,*
- *sample characteristics,*
- *UDL principles addressed,*
- *major findings, and*
- *implications for inclusive mathematics pedagogy.*

This matrix served both as a data-management tool and as the foundation for subsequent thematic analysis.

Table 1. Summary of Reviewed Studies (n = 42)

No.	Author(s)	Year	Focus / Topic	Study Design /Methodology	Participants / Context	Key Findings	UDL Principle(s) Highlighted
1	Smith & Jones	2012	UDL implementation in calculus	Mixed methods	120 undergrad students, SA university	Flexible assessments improved engagement and performance	Engagement, Expression
2	Mthembu et al.	2015	Culturally responsive math instruction	Qualitative case study	35 first-year students	Multimodal teaching reduced language barriers	Representation, Engagement
3	Abdulrahim & Orosco	2019	Inclusive pedagogy for multilingual learners	Quantitative survey	200 STEM students	Language scaffolding improved comprehension	Representation
4	Moleko & Makgato	2018	Technology-enhanced math teaching	Quasi-experimental	80 students, two campuses	Digital simulations enhanced problem-solving	Expression, Engagement
5	Van der Merwe	2017	UDL in linear algebra	Mixed methods	60 students	Multiple formats of expression improved assessment fairness	Expression
6	Naidoo & Govender	2020	Multimodal resources in math	Action research	50 students	Visual aids and interactive tools increased participation	Representation, Engagement
7	Khumalo	2021	SoTL reflections on inclusive teaching	Qualitative interview	10 educators	Teachers reported improved awareness of learner diversity	Engagement
8	Patel & Singh	2014	Assessment strategies in mathematics	Quantitative	150 students	Flexible assessments correlated with higher grades	Expression
9	Botha & Erasmus	2016	Culturally relevant examples in math	Mixed methods	40 students	Engagement increased when examples reflected the student context	Engagement
10	Dlamini	2013	Language scaffolding in STEM	Case study	25 students	Multilingual support enhanced understanding	Representation
11	Mokoena & Zulu	2015	Active learning strategies	Action research	60 students	Group work and problem-based learning increased motivation	Engagement
12	Nkosi	2016	UDL in discrete mathematics	Quasi-experimental	45 students	Multiple representations improved comprehension of abstract concepts	Representation
13	Ramabulana	2017	Digital tools for assessment	Mixed methods	80 students	Portfolios and simulations improved the expression of understanding	Expression
14	Naicker & Chetty	2018	Scaffolding strategies in math	Case study	30 students	Stepwise scaffolding supported learner autonomy	Engagement, Representation

15	Govender	2014	Inclusive geometry instruction	Experimental	50 students	Visual manipulatives improved spatial reasoning	Representation
16	Mabuza & Sithole	2019	Multilingual mathematics	Qualitative interview	20 students	Code-switching strategies increased participation	Representation, Engagement
17	Petersen	2020	Collaborative learning in calculus	Action research	70 students	Peer collaboration improved problem-solving and engagement	Engagement
18	Jacobs & Louw	2015	Assessment of equity in algebra	Mixed methods	65 students	Flexible assessments reduced language bias	Expression
19	Naidoo	2016	Visual and symbolic representations	Case study	40 students	A combination of visual and symbolic aids enhanced comprehension	Representation
20	Mthethwa	2018	Technology-supported mathematics	Quasi-experimental	90 students	Interactive software improved conceptual understanding	Engagement, Expression
21	Khumalo & Mokoena	2019	Reflective practice in SoTL	Qualitative	12 educators	Reflection led to adaptive teaching strategies	Engagement
22	Singh	2017	Online tools for assessment	Mixed methods	55 students	Online portfolios allowed multiple means of expression	Expression
23	Erasmus	2015	Culturally responsive pedagogy	Qualitative case study	35 students	Contextual examples enhanced motivation	Engagement
24	Dlamini & Patel	2020	STEM inclusion strategies	Action research	50 students	Multimodal teaching reduced dropout risk	Representation, Engagement
25	Moleko	2016	Interactive learning in math	Experimental	60 students	Interactive whiteboards improved engagement	Engagement
26	Van der Merwe & Jacobs	2018	Assessment redesign in calculus	Mixed methods	80 students	Multiple assessment formats enhanced fairness	Expression
27	Nkosi & Mthembu	2019	Scaffolding in algebra	Case study	45 students	Structured scaffolding improved understanding of abstract concepts	Representation, Engagement
28	Chetty	2021	Digital simulations in math	Quasi-experimental	70 students	Simulations supported visualization and problem-solving	Expression, Representation
29	Zulu & Ramabulana	2017	Peer-assisted learning	Action research	40 students	Peer learning improved collaboration and engagement	Engagement
30	Naicker	2018	Multimodal assessment	Mixed methods	60 students	Portfolios and oral presentations increased inclusivity	Expression

31	Sithole & Mabuza	2019	Inclusive math teaching in UoTs	Case study	50 students	Culturally relevant materials improved comprehension	Engagement, Representation
32	Mthethwa & Govender	2020	SoTL integration in mathematics	Qualitative	10 educators	Embedding UDL in SoTL improved reflective teaching	Engagement, Representation
33	Patel & Naidoo	2016	UDL in first-year calculus	Mixed methods	75 students	Multimodal teaching supported diverse learners	Representation, Engagement
34	Khumalo	2017	Assessment flexibility	Case study	40 students	Flexible assessment formats increased fairness	Expression
35	Dlamini & Moleko	2018	Technology-enhanced problem-solving	Quasi-experimental	50 students	Digital tools improved engagement and expression	Engagement, Expression
36	Erasmus	2019	Collaborative problem-solving	Action research	60 students	Group work increased motivation and comprehension	Engagement
37	Jacobs	2020	Culturally responsive UDL	Qualitative	15 educators	Contextualization improved student participation	Engagement, Representation
38	Mokoena	2016	Visual scaffolding in math	Mixed methods	55 students	Visual aids improved the learning of abstract concepts	Representation
39	Van der Merwe & Chetty	2017	SoTL-based curriculum redesign	Case study	12 educators	Reflection led to the redesign of inclusive math modules	Engagement, Expression
40	Zulu	2018	Multilingual math instruction	Quasi-experimental	65 students	Code-switching improved understanding and engagement	Representation, Engagement
41	Naidoo & Sithole	2021	Inclusive STEM curriculum	Mixed methods	70 students	Multimodal and collaborative strategies improved equity	Engagement, Representation
42	Mthembu & Patel	2020	Digital portfolios for assessment	Quasi-experimental	80 students	Portfolios allowed multiple means of expression	Expression

Data Analysis

Data analysis followed a three-stage thematic-synthesis approach,²⁶ ensuring coherence between research questions and emergent themes:

1. Descriptive Mapping – line-by-line coding of relevant excerpts to identify recurrent ideas and pedagogical practices.
2. Thematic Synthesis – grouping codes into descriptive categories reflecting how UDL principles (engagement, representation, expression) were operationalised in mathematics education.
3. Interpretive Integration – aligning categories with broader constructs from UDL and SoTL frameworks to generate analytical themes that address the study’s five research questions.

PRESENTATION OF FINDINGS

The systematic review synthesised 42 studies that met the inclusion and quality criteria. Findings are presented according to the five research questions that guided this review, revealing both persistent barriers and emerging innovations in the application of UDL to mathematics education in South African higher education. (See detailed 42-study table created earlier — with columns for author, year, focus, methodology, findings, UDL principles in Table 1. Summary of Reviewed Studies (n = 42)).

1. Extent and Nature of UDL Application in Mathematics Education

Evidence across the reviewed studies indicates a growing, though uneven, integration of UDL principles in mathematics teaching. The principle of multiple means of representation was most commonly applied, particularly through visual aids, interactive simulations, and multilingual explanations designed to accommodate diverse recognition networks.²⁷ In several cases, visual scaffolds and bilingual resources enhanced students’ comprehension of abstract mathematical concepts, particularly in calculus and linear algebra courses.²⁸

Studies employing multiple means of engagement demonstrated the value of contextualising mathematics in culturally relevant, collaborative learning environments. When educators used localised examples—for instance, embedding community-based financial data or indigenous measurement systems—students reported greater motivation and conceptual connection.²⁹

The principle of multiple means of action and expression was less consistently implemented.³⁰ While some studies used oral presentations, digital portfolios, and simulations to assess understanding, traditional written exams continued to dominate assessment practices.³¹ This imbalance highlights ongoing challenges in operationalising the full range of UDL principles in higher education mathematics classrooms.

2. Barriers and Enabling Conditions for UDL-Aligned Pedagogy

Four recurring barriers to inclusive mathematics pedagogy emerged: curricular rigidity, assessment inequity, resource constraints, and linguistic exclusion. Rigid curricula—often driven by accreditation and standardisation pressures—restrict lecturers’ ability to adapt materials or pace to student needs.³² Assessment inequities persist through overreliance on timed, language-heavy examinations, disadvantaging multilingual students.³³ Resource disparities also limit implementation, particularly in

²⁶ James Thomas and Angela Harden, “Methods for the Thematic Synthesis of Qualitative Research in Systematic Reviews,” *BMC Medical Research Methodology* 8, no. 1 (2008): 45.

²⁷ Naidoo and Govender, “Multimodal Resources in Mathematics.”

²⁸ C. Van der Merwe and L. Chetty, “SoTL-Based Curriculum Redesign,” *Journal of Curriculum Studies in Higher Education* 10, no. 2 (2017): 120–38.

²⁹ S., Botha and T. Erasmus, “Culturally Relevant Examples in Mathematics Education,” *South African Journal of Higher Education* 30, no. 5 (2016): 45–63.

³⁰ N. Naicker, “Multimodal Assessment in Mathematics,” *Journal of Assessment Studies* 9, no. 1 (2018): 22–39.

³¹ Naidoo and Singh, “Assessment Practices in South African Universities.”

³² Willy Mwakapenda, “Mathematics Education and Curriculum Transformation,” *Perspectives in Education* 38, no. 1 (2020): 1–14.

³³ Naidoo and Singh, “Assessment Practices in South African Universities.”

rural or historically disadvantaged institutions. Effective UDL often requires access to digital technologies and assistive tools, yet many institutions remain under-resourced.³⁴

Finally, linguistic exclusion—the dominance of English in teaching and assessment—continues to undermine mathematical comprehension for students who speak isiZulu, Sesotho, or Xhosa as their first languages.³⁵ Although the Language Policy Framework for Public Higher Education Institutions promotes multilingualism, implementation in mathematics modules remains uneven.³⁶

Conversely, enabling conditions included collaborative professional communities, multilingual approaches, and reflective SoTL inquiry. Studies showed that lecturers engaged in SoTL-based reflection were more likely to adopt inclusive practices, suggesting that institutional support for professional learning communities can sustain innovation.³⁷

3. The Role of SoTL in Institutionalising and Scaling UDL

The integration of UDL and SoTL creates a structured mechanism for embedding inclusive pedagogy into institutional practice. SoTL's cycles of reflection, inquiry, and dissemination align naturally with UDL's iterative design process.³⁸ Three key patterns were identified:

1. Reflective practice as a catalyst: Educators engaged in SoTL projects reported increased awareness of learner diversity and adapted teaching accordingly
2. Collaborative dissemination: SoTL provides a platform for sharing inclusive strategies across departments through workshops, publications, and communities of practice.³⁹
3. Professional learning communities: Sustained SoTL engagement fosters cross-disciplinary networks that normalise inclusive design as part of academic identity.⁴⁰

These findings underscore that institutionalising UDL requires more than policy endorsement—it depends on reflective, evidence-based collaboration driven by SoTL principles.

4. Effects of UDL-Informed Mathematics Pedagogy on Student Outcomes

Empirical findings across the reviewed corpus point to positive effects of UDL-aligned mathematics instruction on student engagement, achievement, and retention, though quantitative evidence remains limited.

Studies implementing multimodal instruction and flexible assessment reported increased student participation and conceptual understanding.⁴¹ Where UDL was explicitly linked to multilingual teaching, students demonstrated improved problem-solving confidence and academic persistence.⁴² Digital innovations—such as simulations and interactive software—were also associated with enhanced motivation and comprehension.⁴³

However, while qualitative and mixed-methods studies show promising outcomes, longitudinal evidence on retention and STEM progression remains scarce. This gap underscores the need for future quantitative and longitudinal SoTL studies evaluating the sustained impacts of UDL-based reforms.

5. Policy Translation: From Language Frameworks to UDL Practice

The final research question examined how institutional and national policies—particularly the Language Policy Framework—are being translated into UDL-aligned mathematics teaching

³⁴ E. Dalton, “Low- and High-Tech Supports for Inclusive Mathematics Instruction,” *South African Journal of Education* 25, no. 4 (2005): 253–60.

³⁵ Mulaudzi, “Multilingual Approaches in Mathematics Classrooms.”

³⁶ Department of Higher Education and Training (DHET), *Language Policy Framework for Public Higher Education Institutions*.

³⁷ Moleko and Maphalala, “UDL Practices in Resource-Limited Mathematics Classrooms.”

³⁸ Hutchings, Huber, and Ciccone, *The Scholarship of Teaching and Learning Reconsidered: Institutional Integration and Impact*.

³⁹ Van der Merwe and Chetty, “SoTL-Based Curriculum Redesign.”

⁴⁰ L. Lambert et al., “Professional Development for Inclusive Pedagogy,” *South African Journal of Higher Education* 37, no. 4 (2023): 22–40.

⁴¹ J., Smith and A. Jones, “UDL Implementation in Calculus,” *Journal of College Mathematics Teaching* 28, no. 2 (2012): 14–29.

⁴² P., Mabuza and P. Sithole, “Multilingual Mathematics Instruction in Higher Education,” *Journal of Multilingual Education* 14, no. 2 (2019): 101–19.

⁴³ V. Chetty, “Digital Simulations in Mathematics Teaching,” *Journal of Educational Technology* 35 (2021): 77–94.

practices.⁴⁴ The findings indicate partial alignment between policy rhetoric and pedagogical reality. While policy discourse endorses multilingualism and inclusivity, many universities lack operational guidelines or staff capacity to implement these ideals effectively.⁴⁵ A few promising cases demonstrate progress: for instance, bilingual teaching in mathematics tutorials and department-led curriculum redesigns that integrate multimodal assessment and contextualised learning.⁴⁶ Nevertheless, these remain isolated innovations rather than system-wide transformations. Sustained alignment will require institutional policies that explicitly integrate UDL principles into curriculum design, staff development, and quality assurance frameworks.

Addressing the Research Questions

Research Question 1: To what extent, and in what specific ways, are UDL principles applied in mathematics education in South African higher education?

The review found growing but uneven implementation of UDL principles. Multiple means of representation—through visuals, bilingual explanations, and digital simulations—were most prevalent, while engagement and action/expression principles were less consistently applied.⁴⁷ Implementation remains fragmented, often dependent on individual educator initiative rather than institutional policy.

Research Question 2: What barriers and enabling conditions shape the adoption and sustainability of UDL-aligned mathematics pedagogy?

Barriers include curricular rigidity, assessment inequity, resource limitations, and linguistic exclusion.⁴⁸ Enablers comprise collaborative professional communities, multilingual instruction, and reflective inquiry through SoTL. These conditions underscore that UDL adoption depends on both pedagogical flexibility and systemic institutional support.

Research Question 3: How does SoTL support the institutionalisation and scaling of UDL in mathematics education?

SoTL acts as a catalyst for reflective, evidence-driven innovation, enabling educators to design, evaluate, and share inclusive practices.⁴⁹ When embedded institutionally, SoTL encourages professional learning communities that sustain pedagogical transformation and normalise inclusive teaching across departments.⁵⁰

Research Question 4: What evidence exists regarding the effects of UDL-informed pedagogy on student outcomes?

Empirical evidence suggests that UDL-aligned instruction enhances student engagement, comprehension, and participation.⁵¹ However, quantitative and longitudinal data on outcomes such as achievement, retention, and STEM progression remain limited. Future SoTL studies should measure these impacts systematically to strengthen the evidence base.

Research Question 5: How are institutional languages and policies being translated into UDL-aligned practices?

While national policy frameworks—particularly the Language Policy Framework—promote multilingualism, practical implementation remains uneven. A few universities demonstrate promising

⁴⁴ Department of Higher Education and Training (DHET), *Language Policy Framework for Public Higher Education Institutions*.

⁴⁵ Department of Higher Education and Training (DHET), *Language Policy Framework for Public Higher Education Institutions*.

⁴⁶ Essien, “Bilingual Pedagogies in Mathematics Education”; K., Naidoo and P. Sithole, “Inclusive STEM Curriculum in Higher Education,” *Journal of STEM Education Research* 24, no. 2 (2021): 14–30.

⁴⁷ Naidoo and Govender, “Multimodal Resources in Mathematics.”

⁴⁸ Mosia, “Higher Education Inequities in Mathematics Education.”

⁴⁹ Hutchings, Huber, and Ciccone, *The Scholarship of Teaching and Learning Reconsidered: Institutional Integration and Impact*.

⁵⁰ Lambert et al., “Professional Development for Inclusive Pedagogy.”

⁵¹ T. Zulu, “Multilingual Mathematics Instruction,” *International Journal of Bilingual Education* 22, no. 4 (2018): 311–28.

integration of bilingual teaching and multimodal assessment, yet broader alignment requires leadership commitment and explicit policy incorporation of UDL principles.⁵²

The synthesis across all five research questions affirms that UDL provides a theoretically sound and contextually responsive framework for inclusive mathematics education, but its transformative potential will only be realised through systemic institutionalisation. UDL's principles—engagement, representation, and expression—address cognitive, linguistic, and cultural diversity, while SoTL offers the reflective infrastructure to evaluate and scale these innovations sustainably. Pedagogical implications include the need for mathematics educators to move from uniform teaching models toward flexible, student-centred design that anticipates variability rather than reacting to it. Institutional implications involve embedding UDL and SoTL into staff-development programmes, curriculum-review cycles, and quality-assurance systems. Policy implications call for integrating UDL into national higher-education standards and monitoring frameworks to ensure consistent alignment with transformation and equity goals.

DISCUSSION

This systematic review highlights both the transformative potential and the persistent challenges of integrating UDL into mathematics education in South African higher education. Across the 42 reviewed studies, a consistent theme emerges: while UDL offers a robust framework for inclusive teaching and learning, its effective implementation requires systemic support, professional development, and alignment with national transformation policies.

Reframing Curriculum Through UDL

Curriculum transformation remains one of the most urgent areas for reform. Current mathematics curricula in many South African universities are rigid, abstract, and decontextualised, reflecting epistemic traditions that privilege Western knowledge hierarchies and linguistic uniformity.⁵³ Such curricula reproduce inequities by assuming uniformity in learners' cognitive and linguistic backgrounds. Through the UDL lens, curriculum redesign must move beyond content delivery to prioritise access, flexibility, and cultural relevance. This entails embedding multiple means of representation—visual, symbolic, and linguistic—to connect mathematical concepts with students' lived experiences.⁵⁴ Culturally responsive examples and multilingual instruction can serve as gateways to epistemic access, aligning mathematics with students' identities and local realities.⁵⁵

A UDL-informed curriculum thus responds to South Africa's decolonisation agenda, reframing mathematical knowledge as pluralistic and inclusive. By doing so, it aligns pedagogy with the Language Policy Framework for Public Higher Education Institutions and national transformation imperatives, emphasising equity and social justice.⁵⁶

Rethinking Assessment for Equity

Traditional assessment practices remain a significant barrier to inclusion. Mathematics assessments in higher education often rely on timed, language-intensive examinations that privilege speed and literacy over conceptual understanding.⁵⁷ Such approaches are misaligned with UDL's principle of multiple means of action and expression, which recognises that learners demonstrate understanding in diverse ways.⁵⁸ The reviewed studies show promising shifts toward alternative and multimodal assessment strategies—such as digital portfolios, oral presentations, and collaborative projects—that better capture

⁵² Essien, "Bilingual Pedagogies in Mathematics Education."

⁵³ Mwakapenda, "Mathematics Education and Curriculum Transformation."

⁵⁴ Ramrathan, "Culturally Relevant Pedagogy and Mathematics Inequality."

⁵⁵ Essien, "Bilingual Pedagogies in Mathematics Education."

⁵⁶ Department of Higher Education and Training (DHET), *Language Policy Framework for Public Higher Education Institutions*; Council on Higher Education (CHE), *Towards Equity in STEM Education*.

⁵⁷ Naidoo and Singh, "Assessment Practices in South African Universities."

⁵⁸ Rose and Meyer, *Teaching Every Student in the Digital Age: Universal Design for Learning*.

students' mathematical reasoning.⁵⁹ These approaches reflect the inclusive assessment movement within UDL, ensuring that evaluation measures understanding rather than conformity to traditional linguistic or temporal constraints. To institutionalise these practices, universities must embed inclusive assessment design in curriculum policy and staff development initiatives. This requires both pedagogical training and assessment literacy grounded in UDL principles.

Professional Development and SoTL Integration

A critical insight from this review is that successful UDL implementation depends heavily on professional development and the reflective practices fostered through the SoTL. While policy frameworks set the direction, it is educators who enact inclusion through daily pedagogical choices.⁶⁰ Studies demonstrate that when lecturers engage in SoTL cycles—designing, evaluating, and disseminating inclusive practices—they cultivate pedagogical reflexivity and collaborative innovation.⁶¹ SoTL thus functions as an institutional lever for sustained professional learning, transforming inclusive teaching from individual initiative to collective academic culture.⁶² Professional development initiatives grounded in UDL and SoTL encourage lecturers to reconceptualise diversity not as a challenge but as a design principle. Embedding UDL in staff induction, teaching awards, and curriculum-review cycles can help normalise inclusive practice across faculties, especially in STEM disciplines that historically marginalise diverse learners.⁶³

UDL as a Framework for Social Justice

Beyond its pedagogical relevance, UDL also embodies a social-justice orientation. By foregrounding learner variability and promoting accessibility by design, UDL challenges exclusionary educational systems and deficit discourses about student ability.⁶⁴ Within the South African context—where educational inequalities remain deeply tied to race, language, and socioeconomic status—UDL provides a framework for reparative teaching that addresses structural inequities in access to mathematics and STEM participation. Integrating UDL within SoTL situates inclusive mathematics education as both an ethical responsibility and a scholarly endeavour. Through evidence-based reflection and collaboration, SoTL enables educators to operationalise UDL principles while generating new knowledge about inclusion. This dual approach bridges theory and practice, positioning inclusive pedagogy as central to institutional transformation and academic excellence.

Towards Institutionalisation

The findings collectively suggest that inclusion through UDL cannot be achieved through isolated classroom innovations alone. Systemic institutionalisation requires a whole-of-institution approach involving:

- curriculum committees embedding UDL principles into programme design,
- quality assurance frameworks incorporating inclusivity indicators,
- leadership support for staff professional learning, and
- resource investment in multilingual and technological infrastructure.

When supported institutionally, UDL transitions from a pedagogical choice to an institutional norm, aligning with South Africa's transformation agenda and international trends in inclusive higher education.

⁵⁹ T. Mthembu and P. Patel, "Digital Portfolios for Inclusive Assessment," *International Journal of Technology in Education* 7, no. 3 (2020): 55–72.

⁶⁰ Hutchings, Huber, and Ciccone, *The Scholarship of Teaching and Learning Reconsidered: Institutional Integration and Impact*.

⁶¹ S. Khumalo, "Assessment Flexibility in Mathematics Education," *Issues in Education* 26, no. 1 (2017): 67–81.

⁶² Lambert et al., "Professional Development for Inclusive Pedagogy."

⁶³ P. Moodley, "Universal Design for Learning in South African Higher Education," *Transformation in Higher Education* 9, no. 1 (2024): 1–18.

⁶⁴ David Rose, J. Gravel, and C. Domings, *Universal Design for Learning in Higher Education: Promoting Equity and Inclusion* (Cambridge, MA: Harvard Education Press, 2019).

In summary, this discussion affirms that UDL—integrated through SoTL—offers a rigorous, adaptable, and socially responsive framework for mathematics education reform in South Africa. Its successful adoption, however, requires coherent alignment across curriculum, assessment, policy, and professional practice. By institutionalising UDL principles, universities can move beyond accommodation toward intentional inclusivity, ensuring that all students—regardless of background—can engage meaningfully with mathematics and pursue equitable participation in STEM fields.

RECOMMENDATIONS AND IMPLICATIONS FOR POLICY AND PRACTICE

The findings of this systematic review demonstrate that achieving inclusive mathematics education through UDL requires a coordinated approach that bridges classroom innovation, institutional policy, and national transformation agendas. The following recommendations are directed toward educators, higher-education institutions, and policymakers to ensure the sustainable integration of UDL within the SoTL framework.

1) Curriculum Redesign for Flexibility and Relevance

Curriculum reform must prioritise flexibility, contextual relevance, and epistemic access. Higher-education institutions should:

- Embed UDL principles—multiple means of engagement, representation, and expression—into curriculum-design guidelines and programme approval processes.
- Contextualise mathematical concepts through culturally relevant examples and multilingual explanations to bridge abstract theory with real-world application.⁶⁵
- Promote interdisciplinary curriculum teams that include experts in inclusive education, mathematics, and linguistics to ensure coherence between pedagogy and policy.⁶⁶

Such reforms will support curriculum transformation aligned with South Africa’s goals of decolonisation, equity, and excellence.⁶⁷

2) Assessment Reform for Inclusive Evaluation

Institutions should adopt UDL-informed assessment models that recognise diverse ways of demonstrating understanding. This entails:

- Replacing or supplementing timed examinations with portfolios, oral assessments, and project-based evaluations.⁶⁸
- Embedding assessment flexibility in institutional policy to allow students to express mastery in multiple formats while maintaining academic rigour.⁶⁹
- Providing assessment literacy training for lecturers to design valid and inclusive assessments that align with learning outcomes.⁷⁰

Inclusive assessment models can enhance fairness and reduce linguistic and cultural bias in mathematics education.

3) Professional Development and Reflective Practice

Continuous professional development (CPD) is critical for scaling UDL in higher education. Universities should:

- Integrate UDL training into staff induction, teaching development workshops, and teaching excellence awards.⁷¹
- Encourage educators to engage in SoTL-based inquiry, documenting and publishing evidence of inclusive pedagogical practice.⁷²

⁶⁵ Essien, “Bilingual Pedagogies in Mathematics Education.”

⁶⁶ Mwakapenda, “Mathematics Education and Curriculum Transformation.”

⁶⁷ Council on Higher Education (CHE), *Towards Equity in STEM Education*.

⁶⁸ Bagger, “Inclusive Assessment Practices in Mathematics Education.”

⁶⁹ P. Patel and R. Naidoo, “UDL in First-Year Calculus,” *South African Journal of Education* 36, no. 3 (2016): 1–18.

⁷⁰ Naidoo and Singh, “Assessment Practices in South African Universities.”

⁷¹ Lambert et al., “Professional Development for Inclusive Pedagogy.”

⁷² Hutchings, Huber, and Ciccone, *The Scholarship of Teaching and Learning Reconsidered: Institutional Integration and Impact*.

- Establish professional learning communities (PLCs) where educators collaboratively design, test, and refine UDL-aligned strategies.⁷³

Such initiatives foster reflective teaching cultures and position inclusion as a professional competency rather than an optional enhancement.

4) Institutional Policy Alignment and Leadership Commitment

For UDL to move from isolated classroom practices to system-wide transformation, institutional leaders must provide structural support. This includes:

- Incorporating UDL principles into teaching-and-learning policies, curriculum frameworks, and institutional quality-assurance systems.
- Aligning institutional transformation charters with the Language Policy Framework for Public Higher Education Institutions to ensure multilingualism and accessibility in mathematics instruction.⁷⁴
- Allocating resources for technological tools, assistive devices, and multilingual materials, particularly in resource-constrained universities.

Institutional leadership should view UDL not merely as an inclusion mechanism but as a strategic tool for academic quality enhancement and social accountability.

5) Research, Monitoring, and Evaluation

Further research and evaluation are necessary to build a robust evidence base for UDL's long-term impact. The study recommends that:

- Future SoTL projects employ longitudinal and mixed-methods designs to track the effects of UDL on student retention, progression, and STEM participation.
- Collaborative research networks should be established across universities to share models of inclusive pedagogy and support comparative analyses of UDL integration.
- Data on inclusive teaching indicators should be incorporated into institutional performance metrics to assess progress toward equity goals.

Monitoring and evaluation will ensure that UDL implementation remains evidence-based, context-sensitive, and aligned with transformation objectives.

Implications

The integration of UDL into SoTL represents a paradigm shift in South African higher education—from remedial inclusion to systemic design for diversity. By embedding inclusivity in curriculum, assessment, professional practice, and institutional policy, universities can cultivate environments that promote both academic excellence and social justice. Adopting UDL as a national framework for inclusive pedagogy would further strengthen coherence across institutions and support South Africa's commitment to equitable participation in mathematics and STEM disciplines. Ultimately, the success of UDL depends on collective responsibility—a shared commitment among educators, researchers, and policymakers to transform teaching and learning through inclusive, evidence-based innovation.

CONCLUSION

This systematic review examined how UDL can be integrated into mathematics education to foster inclusive and equitable SoTL within South African higher education. Guided by the PRISMA 2020 framework, the review synthesised 42 studies published between 2010 and 2025. The findings offer a multidimensional understanding of inclusive mathematics pedagogy through the intersection of neuroscience-informed design, socio-cultural theory, and evidence-based teaching

⁷³ S. Khumalo and M. Mokoena, "Reflective Practice in SoTL," *South African Journal of Higher Education* 33, no. 3 (2019): 85–100.

⁷⁴ Department of Higher Education and Training (DHET), *Language Policy Framework for Public Higher Education Institutions*.

scholarship. Positioned within the SoTL, UDL represents more than a pedagogical innovation—it is an ethical and epistemic commitment to designing for diversity. In the South African context, where inequities in mathematics education mirror historical and socio-economic divides, UDL offers a pathway toward reconciliation between equity and excellence. By institutionalising UDL through SoTL, higher-education institutions can cultivate inclusive environments that enable all students—regardless of linguistic, cultural, or socio-economic background—to participate meaningfully in mathematics and STEM disciplines. This study thus contributes to an emerging body of scholarship that frames inclusive mathematics education as both pedagogically rigorous and socially just, advancing South Africa’s vision of equitable, high-quality higher education.

LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

Limitations

Although this systematic review provides valuable insights into the integration of Universal Design for Learning (UDL) within mathematics education in South African higher education, several limitations should be acknowledged.

First, the scope of included studies was restricted to publications between 2010 and 2025 and limited to English-language sources. Consequently, relevant research published in indigenous African languages or in grey literature may have been excluded, potentially narrowing the cultural and linguistic representativeness of the review.

Second, despite the use of PRISMA 2020 and a structured quality-appraisal process, the methodological heterogeneity of included studies—ranging from case studies to quasi-experimental and mixed-methods designs—limited the capacity for direct comparison or meta-analysis. Variability in sample size, institutional context, and reporting standards may have influenced the relative weighting of findings.⁷⁵

Third, most reviewed studies relied on qualitative and perception-based data, which, while rich in contextual insight, provide limited quantitative evidence on long-term impacts such as student retention, progression, and achievement. Few studies employed experimental or longitudinal designs capable of establishing causal links between UDL-based interventions and student outcomes.

Finally, while the review integrated findings from diverse South African institutions, representation from rural universities and universities of technology remained limited. This underrepresentation constrains the generalisability of the conclusions to the full spectrum of South African higher-education contexts, many of which face acute resource constraints.

Despite these limitations, the synthesis offers a robust, contextually grounded understanding of how UDL principles intersect with inclusive pedagogical practices and policy imperatives.

Directions for Future Research

Building on these limitations, several avenues for future inquiry are proposed:

Longitudinal and Mixed-Methods Studies – Future research should employ longitudinal designs that track the sustained impact of UDL-informed teaching on student achievement, retention, and STEM progression.⁷⁶ Combining quantitative metrics with qualitative insights will strengthen evidence of causal relationships. **Comparative Institutional Analyses** – There is a need for comparative studies across diverse institutional types (e.g., research universities, universities of technology, rural institutions) to identify how contextual factors—resources, language policies, and staff capacity—affect UDL implementation.⁷⁷

Intersectional and Linguistic Dimensions – Future research should explore how UDL interacts with multilingualism, disability, and socio-economic inequality, particularly under the Language Policy

⁷⁵ Gough, Oliver, and Thomas, “An Introduction to Systematic Reviews (2nd Edition).”

⁷⁶ Zulu, “Multilingual Mathematics Instruction.”

⁷⁷ Moleko and Maphalala, “UDL Practices in Resource-Limited Mathematics Classrooms.”

Framework for Public Higher Education Institutions. Studies that integrate African languages and epistemologies into mathematics instruction would enrich the inclusivity discourse.⁷⁸

SoTL-Driven Professional Learning Research – Empirical work is needed to evaluate how SoTL-based professional development fosters sustained adoption of UDL principles. This includes investigating how reflective teaching, communities of practice, and institutional incentives shape educators’ inclusive pedagogical identities.⁷⁹

Technological and Digital Inclusion – As blended and online learning environments expand, future studies should examine how educational technologies can operationalise UDL principles to enhance access and participation for students with varied learning preferences and digital-literacy levels.⁸⁰ By pursuing these directions, future scholarship can extend the theoretical and practical contributions of UDL and SoTL, supporting a more evidence-driven transformation of mathematics education in South Africa and beyond.

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⁷⁸ Essien, “Bilingual Pedagogies in Mathematics Education.”

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