Transforming Mathematics Teacher Competencies in Small States: An ODL and TEL Approach to Sustainable Professional Development

Dr Schontal Moore [1] and Dr Lois George [2]

1. Commonwealth of Learning, smoore@col.org
2. University of the West Indies, lois.george@uwi.edu

Abstract

Mathematics proficiency is a critical determinant of educational and professional success. However, across the Caribbean, students continue to struggle with mathematics achievement, largely due to gaps in teacher knowledge and pedagogical skills. Traditional professional development (PD) models have often been inadequate in addressing these gaps, particularly given teachers' time constraints, diverse learning needs, and professional commitments. This paper, as part of Phase 2 of the ongoing Advancing Caribbean Teachers (ACT) in Mathematics project, presents the design of a Technology-Enabled Learning (TEL) and Open and Distance Learning (ODL) model for professional development, aimed at enhancing teacher competencies, beginning with the Eastern Caribbean. Grounded in Carrillo et al.'s Mathematics Teacher's Specialised Knowledge (MTSK) Model, Clarke and Hollingsworth's (2002) Interconnected Model of Teacher Change, and an ODL framework, the programme integrates virtual workshops, a Moodle-based Community of Practice, and Open Educational Resources (OER) to support teacher learning. This paper examines how TEL and ODL principles address existing PD challenges, offering scalable, flexible, and effective alternatives to traditional approaches. The discussion highlights the design of the programme, its potential for sustained professional learning, and its broader implications for building resilient mathematics education communities.

Keywords: Technology-Enabled Learning (TEL), Open and Distance Learning ODL), Mathematics Teacher Professional Development (PD), Communities of Practice (CoP), Open Educational Resources (OER)

Introduction

Mathematics proficiency remains critical for individual advancement and national development, yet the Caribbean continues to grapple with low mathematics achievement (Small, 2024). Within the Anglophone Caribbean region, poor mathematics performance has persisted at all educational levels (Burunciuc, 2025; Small, 2024). For example, in 2024, only 36 per cent of students who took the Caribbean Secondary Education Certificate mathematics examination obtained a passing grade. At the primary level, there is no common examination across all the islands; however, in Saint Lucia, from 2010 to 2019, the average pass rate across Grades 2, 4, and 6 was approximately 58 per cent. This suggests that four out of ten primary school children struggled

with mathematics. In Saint Vincent and the Grenadines, national diagnostic mathematics test results from 2021-2023 revealed a steady decline in student achievement, particularly in Grade 4.

The challenges observed are not isolated to the Caribbean but reflect global patterns where foundational numeracy skills are poorly developed (UNESCO, 2015). Foundational gaps have been shown to have long-term consequences, resulting in lower participation in science, technology, engineering, and mathematics (STEM) fields and reduced economic competitiveness (World Bank, 2020). These trends pose serious developmental risks for small island developing states (SIDS), where human capital is a primary economic asset.

The issue of poor student achievement has been attributed to various factors, including curriculum misalignment, insufficient instructional time, and socio-economic disparities (OECD, 2018). However, Darling-Hammond et al. (2017) identified limited teacher mathematical competencies as a major contributor. Teachers without strong mathematical knowledge for teaching (MKT) often struggle with content delivery, classroom discourse management, and the application of effective instructional strategies, further widening learning gaps (Winheller et al., 2013).

In response to these critical concerns, the Commonwealth of Learning (COL), through its Virtual University for Small States of the Commonwealth (VUSSC), partnered with Ministries of Education in Saint Lucia, Saint Kitts and Nevis, and Saint Vincent and the Grenadines to implement the Advancing Caribbean Teachers (ACT) in Mathematics Project. This initiative was designed to equip in-service teachers with innovative teaching strategies incorporating ODL, TEL, and gender-responsive pedagogy to transform mathematics instruction, particularly in the teaching of fractions and problem-solving. The project represents a significant regional effort to address systemic teacher development needs using innovative, scalable, and sustainable models.

Review of Literature

A substantial body of research affirms that teacher content knowledge and pedagogical expertise are critical determinants of student success (Ball et al., 2008; Chapman, 2013). Studies demonstrate that improvements in teachers' understanding of complex mathematical concepts such as fractions, proportional reasoning, and problem-solving directly influence student learning outcomes (Hecht & Vagi, 2012; Siegler et al., 2010). This is especially critical at the primary level, where foundational mathematical reasoning develops.

The Mathematics Teacher's Specialised Knowledge (MTSK) model proposed by Carrillo et al. (2018) serves as a useful framework for examining the multi-dimensional nature of teacher knowledge. It recognises not only content knowledge but also pedagogical content knowledge (PCK), knowledge of student thinking, and curricular sequencing as key factors in effective teaching. Additionally, Clarke and Hollingsworth's (2002) Interconnected Model of Teacher Change emphasises the dynamic, cyclical, and collaborative nature of professional growth, wherein external stimuli such as professional development (PD) interventions interact with personal practice, reflection, and learning outcomes.

Professional development for mathematics teachers is essential in equipping educators with the specialised knowledge and instructional strategies needed to foster deep conceptual understanding among students. As mathematical concepts become more abstract and cognitively demanding, ongoing PD ensures that teachers remain current with both content knowledge and evolving pedagogical approaches. Without sustained PD, many teachers struggle to address student misconceptions, differentiate instruction, and apply evidence-based methods that support diverse learning needs in mathematics classrooms. For PD to be effective, it must move beyond traditional, one-off workshops towards sustained, practice-embedded learning (Garet et al., 2001). This is particularly important in contexts where teachers face multiple systemic challenges, including large class sizes, resource limitations, and high-stakes accountability pressures (Loucks-Horsley et al., 2010). Sustained learning communities, supported by both institutional leadership and peer networks, have proven to be among the most effective means of embedding instructional change (Wenger, 1998).

The adoption of ODL and TEL frameworks offers significant promise for addressing these professional development challenges, particularly in small states where physical infrastructure and access to face-to-face learning opportunities may be limited (Commonwealth of Learning, 2020; Farrell & Oliveira, 2008). Technology-Enabled Learning creates flexible learning environments that accommodate teachers' demanding schedules while promoting self-paced, asynchronous, and collaborative engagement (Means et al., 2014). For mathematics teachers specifically, these approaches are especially relevant as they allow educators to engage deeply with complex mathematical content, experiment with new instructional technologies, and access global communities of practice that support ongoing learning. Mathematics forms the gateway to STEM fields, which drive much of the region's emerging economic opportunities in areas such as data science, information technology, renewable energy, and advanced manufacturing. As such, building teacher capacity in mathematics through accessible and high-quality PD is not only central to improving student achievement but also vital to developing a skilled STEM-ready workforce that can participate competitively in the global economy. The professional growth of mathematics teachers, therefore, directly contributes to national development goals by ensuring that students acquire the foundational numeracy and problem-solving skills required for future participation in innovation-driven sectors.

Gender-responsive pedagogy further complements effective PD by promoting equitable classroom practices that address persistent gender disparities in mathematics achievement (Unterhalter, 2017; UNESCO, 2015). Evidence suggests that such approaches encourage more active student engagement and reduce achievement gaps, particularly for girls, who often encounter both implicit and explicit biases within mathematics classrooms (OECD, 2018). However, gender responsiveness is not only about addressing disadvantages for girls; it also requires acknowledging that boys and girls often learn differently, express mathematical reasoning differently, and are motivated by different classroom stimuli. Research indicates that boys may gravitate more towards spatial, competitive, or problem-solving tasks, while girls often excel when learning is contextualised through collaborative, applied, or real-world problem situations (Cai et al., 2019; Lindberg et al., 2010). Professional development that exposes

mathematics teachers to differentiated instructional strategies, framed by gender mainstreaming principles, equips them with tools to design learning experiences that resonate with both boys' and girls' preferences, interests, and ways of processing mathematical concepts. This moves PD beyond generic content delivery to more nuanced instructional design, allowing teachers to reach students based on gendered learning styles while also challenging stereotypes that limit potential in STEM participation. Integrating such approaches into PD enables mathematics teachers to move away from rigid, one-size-fits-all models and adopt more dynamic, student-centred practices that ultimately foster higher engagement, deeper learning, and more equitable mathematics outcomes.

The ACT project was intentionally aligned with global and regional policy frameworks, including the Organisation of Eastern Caribbean States (2012) Education Sector Strategy for 2012–2021 and Sustainable Development Goal 4 (SDG 4), emphasising inclusive, equitable, and quality education for all (UNESCO, 2015). This alignment underscores the project's recognition that teacher PD is not an isolated intervention but a systemic lever for both educational reform and broader socio-economic development. By embedding teacher competency-building within these frameworks, the ACT model directly addresses the dual challenges identified earlier: the need for content mastery supported through flexible ODL and TEL modalities, and the importance of pedagogical adaptation that recognises gendered learning differences. Equipping mathematics teachers with the knowledge and tools to deliver differentiated, inclusive instruction ensures that both boys and girls have equal opportunities to succeed in mathematics, a subject foundational to STEM readiness. In doing so, the ACT initiative positions mathematics education reform as central to building national human capital, expanding pathways into high-growth STEM industries, and fostering more equitable participation in innovation-driven economies across the Eastern Caribbean. Thus, the professional growth of mathematics teachers under ACT serves not only the classroom but also the long-term resilience and competitiveness of small island states within the global knowledge economy.

Stemming from the aforementioned, this research focuses on the following question and its related sub-questions.

Main Research Question:

How did the ACT in Mathematics professional development initiative transform mathematics teaching competencies and professional development practices in small states through a technology-enabled, inclusive, and collaborative approach?

Sub-Research Questions:

1. In what ways did the programme deepen teachers' content and pedagogical knowledge for effective mathematics instruction, particularly in the teaching of fractions? (*Core Area 1: Deepening teacher knowledge for mathematics teaching*)

2. How did participation in the ACT programme build teachers' digital pedagogical capacity and confidence in using technology-enabled learning (TEL) tools?
   (*Core Area 2: Building digital pedagogical capacity*)
3. How did the integration of differentiated and gender-responsive strategies influence teachers' classroom practices to support more equitable mathematics learning outcomes?
   (*Core Area 3: Advancing differentiated and gender-responsive pedagogy*)
4. What role did peer-led professional learning structures, such as communities of practice, play in shaping teacher collaboration, reflective practice, and shared problem-solving?
   (*Core Area 4: Strengthening peer-led professional learning*)
5. How did the involvement of school leaders and education officers contribute to cultivating leadership for more sustainable and scalable professional development systems?
   (*Core Area 5: Cultivating leadership for sustainable PD systems*)

Methodology

This study employed a mixed-methods, developmental evaluation design to document and assess the implementation of the ACT in Mathematics Project across three Eastern Caribbean countries: Saint Lucia, Saint Kitts and Nevis, and Saint Vincent and the Grenadines. The research design was primarily qualitative in nature, incorporating both formative and summative components to track participant learning, instructional practice shifts, and programme outcomes over time (Patton, 2010). This approach allowed for continuous reflection and adaptation while capturing rich descriptive data on teacher learning experiences, perceived challenges, and institutional responses related to professional development.

Participants

A total of 84 educators participated in the ACT in Mathematics Project across the three countries. Participants represented a diverse cross-section of educational stakeholders including classroom teachers at the primary level, mathematics coordinators, numeracy coaches, curriculum officers, school principals, and pre-service teacher educators. Participation was coordinated through the Ministries of Education in each country, ensuring inclusion of both frontline practitioners and system-level personnel. Gender representation across cohorts reflected the broader demographic composition of the teaching profession in the region, with a majority female participant group (approximately 75% female, 25% male across sites). The intentional inclusion of district-level leaders and teacher educators provided opportunities for broader systemic alignment and the potential for institutional scaling of effective practices.

Research Design and Intervention

The ACT in Mathematics Project employed a phased, multi-modal professional development model grounded in hybrid learning theory (Darling-Hammond et al., 2017). The programme was delivered in three major phases:

Phase 1: Face-to-Face Training

Each country began with a two-day, in-person workshop focusing on the teaching and learning of fractions, a foundational yet persistently challenging mathematical topic at the primary level which often follows learners through to the secondary level if not addressed (Siegler et al., 2010). The workshops utilised the Concrete-Pictorial-Abstract (CPA) instructional model, emphasising hands-on exploration through physical manipulatives such as fraction tiles, strips, and circles. Workshop sessions modelled culturally responsive pedagogy and gender-sensitive instructional practices to help teachers adapt strategies for diverse learner needs.

Phase 2: Virtual Professional Learning Community

Following the face-to-face sessions, participants engaged in a four-month online professional learning programme using a blended model of synchronous and asynchronous engagement. Synchronous sessions were conducted via Zoom every two to three weeks, providing opportunities for real-time instructional coaching, collaborative problem-solving, and peer feedback. Asynchronous activities were housed on the Moodle platform, which hosted interactive readings, curated Open Educational Resources (OER), lesson development tasks, and digital manipulative tools (e.g., GeoGebra, NRICH).

Phase 3: Community of Practice (CoP)

An online Community of Practice (CoP) served as an ongoing collaborative space for reflection, resource sharing, and mentorship across all country cohorts. Facilitated by mathematics education experts, the CoP allowed participants to engage in joint inquiry, co-create classroom resources, troubleshoot instructional challenges, and build regional professional relationships.

Data Collection and Sources

Multiple data sources were collected to document teacher learning outcomes and assess project effectiveness:

- Pre- and post-intervention self-assessment surveys measuring teacher confidence, content knowledge, and pedagogical competencies related to fraction instruction.
- Participant reflections, learning journals, and lesson artefacts submitted through Moodle.
- Problem-solving task performance and classroom activity design assignments assessed for instructional quality.
- Facilitator observation notes from synchronous sessions and online platform analytics tracking participant engagement.
- Participant workshop evaluations capturing satisfaction with content, delivery methods, and perceived relevance to practice.

Data Analysis

Quantitative data from pre- and post-surveys were analysed using descriptive statistics to track changes in teacher confidence, knowledge, and instructional readiness across demographic groups. Qualitative data from reflections, journals, and forum posts were thematically analysed using Braun and Clarke's (2006) approach to identify patterns in instructional change and

pedagogical growth. Combining both methods allowed for strong triangulation and a comprehensive evaluation of learning outcomes across the three countries.

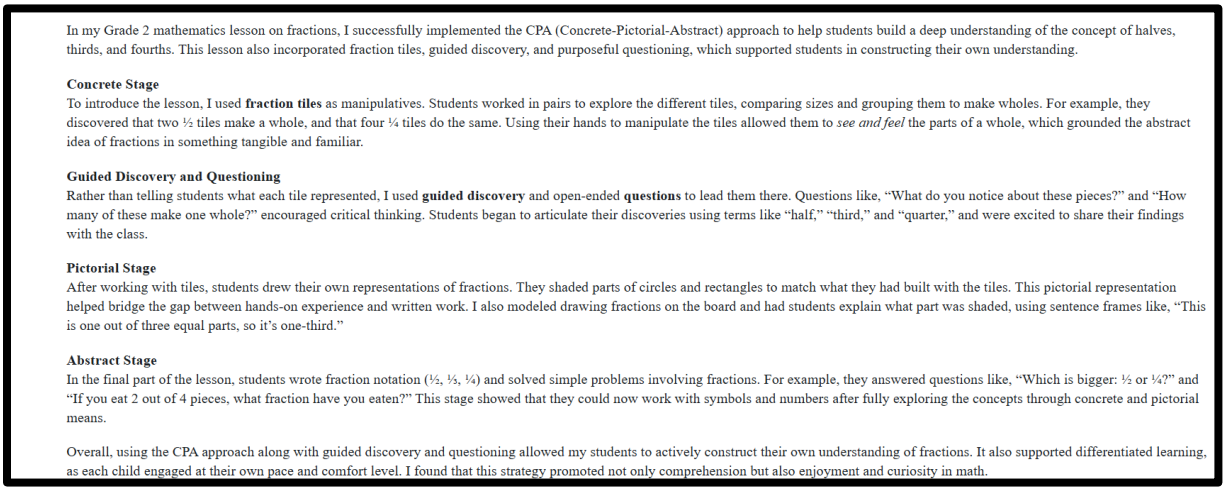
Findings and Discussion

The evaluation of the ACT in Mathematics Project revealed multiple dimensions through which teacher professional development (PD) was enhanced, offering both immediate instructional benefits and longer-term system-wide implications. The findings are organised thematically around five core areas of PD impact: deepening teacher knowledge for mathematics teaching, building digital pedagogical capacity, advancing differentiated and gender-responsive pedagogy, strengthening peer-led professional learning, and cultivating leadership for sustainable PD systems. Together, these themes reflect how PD, when thoughtfully designed and executed, can serve as a transformative mechanism for instructional improvement and institutional growth.

Deepening Teacher Knowledge for Mathematics Teaching

The ACT project strengthened teachers' mathematical knowledge for teaching (MKT) by focusing on fractions and problem-solving which are often challenging areas for both educators and students Hecht & Vagi, 2012; Piñeiro et al., 2024). All participants reported improved confidence, knowledge, and skills for teaching fractions conceptually, as confirmed by post-workshop evaluations and reflective Moodle posts.

Moodle Post 1



In my Grade 2 mathematics lesson on fractions, I successfully implemented the CPA (Concrete-Pictorial-Abstract) approach to help students build a deep understanding of the concept of halves, thirds, and fourths. This lesson also incorporated fraction tiles, guided discovery, and purposeful questioning, which supported students in constructing their own understanding.

Concrete Stage
To introduce the lesson, I used **fraction tiles** as manipulatives. Students worked in pairs to explore the different tiles, comparing sizes and grouping them to make wholes. For example, they discovered that two ½ tiles make a whole, and that four ¼ tiles do the same. Using their hands to manipulate the tiles allowed them to *see and feel* the parts of a whole, which grounded the abstract idea of fractions in something tangible and familiar.

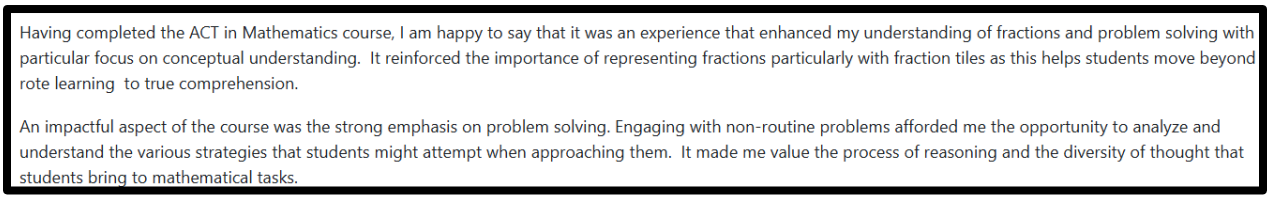
Guided Discovery and Questioning
Rather than telling students what each tile represented, I used **guided discovery** and open-ended **questions** to lead them there. Questions like, "What do you notice about these pieces?" and "How many of these make one whole?" encouraged critical thinking. Students began to articulate their discoveries using terms like "half," "third," and "quarter," and were excited to share their findings with the class.

Pictorial Stage
After working with tiles, students drew their own representations of fractions. They shaded parts of circles and rectangles to match what they had built with the tiles. This pictorial representation helped bridge the gap between hands-on experience and written work. I also modeled drawing fractions on the board and had students explain what part was shaded, using sentence frames like, "This is one out of three equal parts, so it's one-third."

Abstract Stage
In the final part of the lesson, students wrote fraction notation (½, ⅓, ¼) and solved simple problems involving fractions. For example, they answered questions like, "Which is bigger: ½ or ¼?" and "If you eat 2 out of 4 pieces, what fraction have you eaten?" This stage showed that they could now work with symbols and numbers after fully exploring the concepts through concrete and pictorial means.

Overall, using the CPA approach along with guided discovery and questioning allowed my students to actively construct their own understanding of fractions. It also supported differentiated learning, as each child engaged at their own pace and comfort level. I found that this strategy promoted not only comprehension but also enjoyment and curiosity in math.

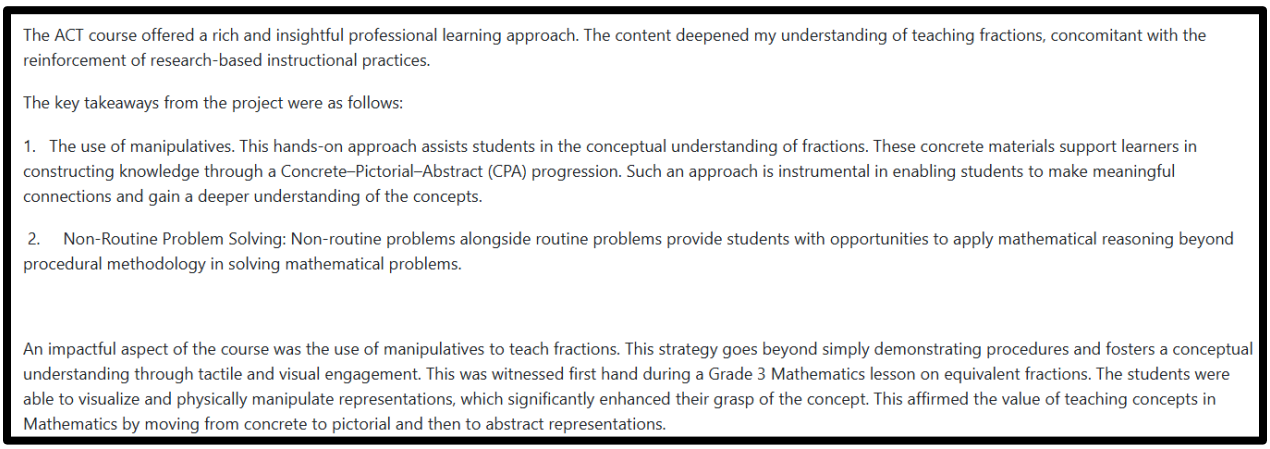
Moodle Post 2



Having completed the ACT in Mathematics course, I am happy to say that it was an experience that enhanced my understanding of fractions and problem solving with particular focus on conceptual understanding. It reinforced the importance of representing fractions particularly with fraction tiles as this helps students move beyond rote learning to true comprehension.

An impactful aspect of the course was the strong emphasis on problem solving. Engaging with non-routine problems afforded me the opportunity to analyze and understand the various strategies that students might attempt when approaching them. It made me value the process of reasoning and the diversity of thought that students bring to mathematical tasks.

Moodle Post 3



The ACT course offered a rich and insightful professional learning approach. The content deepened my understanding of teaching fractions, concomitant with the reinforcement of research-based instructional practices.

The key takeaways from the project were as follows:

1. The use of manipulatives. This hands-on approach assists students in the conceptual understanding of fractions. These concrete materials support learners in constructing knowledge through a Concrete–Pictorial–Abstract (CPA) progression. Such an approach is instrumental in enabling students to make meaningful connections and gain a deeper understanding of the concepts.

2. Non-Routine Problem Solving: Non-routine problems alongside routine problems provide students with opportunities to apply mathematical reasoning beyond procedural methodology in solving mathematical problems.

An impactful aspect of the course was the use of manipulatives to teach fractions. This strategy goes beyond simply demonstrating procedures and fosters a conceptual understanding through tactile and visual engagement. This was witnessed first hand during a Grade 3 Mathematics lesson on equivalent fractions. The students were able to visualize and physically manipulate representations, which significantly enhanced their grasp of the concept. This affirmed the value of teaching concepts in Mathematics by moving from concrete to pictorial and then to abstract representations.

While most teachers felt confident solving routine problems, only 7% rated their students as strong problem solvers. Less than 30 per cent regularly used non-routine problems. By the end of the project, all respondents reported increased confidence in teaching problem-solving.

Supervisor feedback supported these self-assessments, confirming teachers' use of digital and concrete tools, application of the Concrete–Pictorial–Abstract (CPA) approach, and increased confidence in integrating non-routine tasks into instruction.

Consistent with Clarke and Hollingsworth's (2002) Interconnected Model of Teacher Change, participants reported cycles of reflection, application, and refinement as they engaged in practice-based tasks during both the face-to-face workshops and online components. Teachers noted greater confidence in diagnosing student misconceptions and orchestrating classroom discussions that elicited student reasoning—critical features of pedagogical content knowledge (Chapman, 2013).

Building Digital Pedagogical Capacity for Sustained PD Engagement

A key outcome of the ACT initiative was strengthening teachers' ability to use technology-enabled learning (TEL) as both learners and educators. All survey respondents reported improved use of TEL tools and strategies. Supervisors confirmed this, with full agreement on teachers' use of digital and ODL methods to support learning, and three-quarters noting increased student engagement as a result.

Historically, many teachers in small states have had limited exposure to digital PD platforms (Farrell & Oliveira, 2008), which may constrain both their own learning and their ability to integrate technology into classroom practice. The ACT programme directly addressed this gap by embedding Open and Distance Learning (ODL) and Technology-Enabled Learning (TEL) frameworks into the PD design, offering teachers structured exposure to Moodle, Zoom, digital manipulatives, and OER (Commonwealth of Learning, 2020).

Importantly, teachers' engagement with these tools was not limited to passive consumption but required active participation in asynchronous modules, collaborative problem-solving, and

reflective practice. This aligns with Means et al.'s (2014) argument that well-designed online PD can not only replicate but enhance the conditions for adult professional learning, particularly when flexible, personalised, and collaborative structures are embedded. As teachers gained confidence navigating digital platforms for their own PD, many also began transferring these skills into their instructional practice, thereby extending the reach of the programme's impact beyond professional learning into the core of classroom pedagogy.

Advancing Differentiated and Gender-Responsive Pedagogical Expertise

A particularly innovative element of the ACT project was its integration of gender-responsive pedagogy as a critical component of teacher PD. This PD model, encouraged teachers to consider how boys and girls may engage differently with math tasks (Lindberg et al., 2010; Unterhalter, 2017). Teachers reflected on biases and explored strategies to meet diverse learner needs, combining collaborative real-life problems with spatial-competitive tasks (OECD, 2018).

About 90% of participants reported improved use of gender-based strategies post-workshop, rising to 94% in the final survey five months later. Supervisors confirmed these practices in classrooms, noting greater teacher confidence and improved student engagement.

The enactment of differentiated instruction is captured in the following Moodle post that details a participant's engagement with their students in relation to problem-solving.

My students had recently mastered subtraction using the abstract method; however, they were unfamiliar with subtraction involving regrouping. To introduce the concept, I wrote the word **"challenge"** along with a subtraction equation on the board. For some reason, when my students see or hear that word, they become immediately engaged and eager to participate.

My class includes students at varying math levels. As a result, some students immediately used manipulatives to solve the problem. A few attempted to solve it column by column, while about two tried subtracting the entire numbers at once. Eventually, they realized this strategy was not effective and began exploring alternative methods. These are my tactile learners—those who need to see and feel in order to understand.

Other students chose the abstract approach, solving the problem with numbers only until they reached a column where the top digit was smaller than the bottom one. A few students responded by switching the digits (e.g., solving 7 - 4 instead of 4 - 7). I used this moment to guide them in understanding that switching the digits changes the value and meaning of the problem.

To make the concept relatable, I asked them to imagine needing $7 to pay a bill but only having $4. I asked "What would you do to get the rest?". Their answer—"borrow"—led us into a discussion that connected to their prior knowledge of base-ten blocks. We also explored the idea that in addition we share, while in subtraction we borrow —opposites.

After this breakthrough, the students returned to the problem with renewed understanding and began solving on their own. From then on, we used the phrase "being rich and poor"when regrouping in subtraction. At the end students were able to subtract with regrouping confidently, both with and without manipulatives.

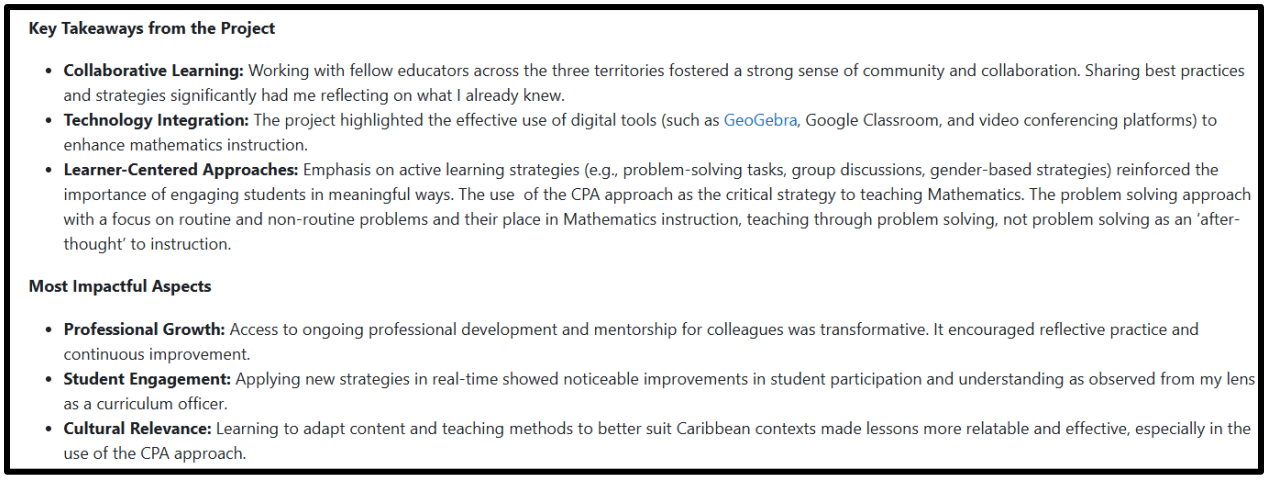
This improved classroom participation, particularly among previously marginalised female students, directly supports the inclusive aims of Sustainable Development Goal 4 (UNESCO, 2015). These professional insights align with the literature advocating for PD that moves beyond technical training into more complex adaptive pedagogies (Loucks-Horsley et al., 2010; Darling-Hammond et al., 2017).

Strengthening Peer-Led Professional Learning through Communities of Practice

The establishment of the Community of Practice (CoP) provided a critical structure for fostering sustained peer-led PD beyond the formal training sessions. Wenger (1998) posits that professional communities are most effective when practitioners share ownership of the learning process, collectively negotiate knowledge, and engage in joint inquiry grounded in real practice. This dynamic was consistently observed throughout the ACT project, where synchronous CoP sessions enabled teachers to co-develop lesson resources, troubleshoot classroom challenges, and adapt new strategies collectively.

In the workshop and final surveys, participants specifically mentioned that they valued "Collaborative discussions" and "interaction with peers". A similar sentiment was communicated in a reflection posted within the Moodle space.

Participant Reflection



Key Takeaways from the Project

- **Collaborative Learning:** Working with fellow educators across the three territories fostered a strong sense of community and collaboration. Sharing best practices and strategies significantly had me reflecting on what I already knew.
- **Technology Integration:** The project highlighted the effective use of digital tools (such as GeoGebra, Google Classroom, and video conferencing platforms) to enhance mathematics instruction.
- **Learner-Centered Approaches:** Emphasis on active learning strategies (e.g., problem-solving tasks, group discussions, gender-based strategies) reinforced the importance of engaging students in meaningful ways. The use of the CPA approach as the critical strategy to teaching Mathematics. The problem solving approach with a focus on routine and non-routine problems and their place in Mathematics instruction, teaching through problem solving, not problem solving as an 'after-thought' to instruction.

Most Impactful Aspects

- **Professional Growth:** Access to ongoing professional development and mentorship for colleagues was transformative. It encouraged reflective practice and continuous improvement.
- **Student Engagement:** Applying new strategies in real-time showed noticeable improvements in student participation and understanding as observed from my lens as a curriculum officer.
- **Cultural Relevance:** Learning to adapt content and teaching methods to better suit Caribbean contexts made lessons more relatable and effective, especially in the use of the CPA approach.

In the Moodle discussion forums, there were spirited exchanges among participants as they discussed aspects of the content or its implementation. Unlike traditional PD models where knowledge flows from external experts, the CoP fostered horizontal learning relationships, allowing teachers to assume leadership roles in sharing emerging practices and innovations. As Clarke and Hollingsworth (2002) emphasise, such collaborative reflection accelerates both individual and collective professional growth, embedding PD into teachers' everyday professional identities. The CoP's cross-country structure further extended the learning community's reach, enabling participants to contextualise their learning while benefiting from regional perspectives on shared instructional challenges.

Cultivating Leadership for Sustainable PD Systems

One of the most promising findings of the ACT project relates to its contribution to institutional leadership development, a frequently underemphasised component of teacher PD design (Darling-Hammond et al., 2017). The intentional inclusion of principals, curriculum officers, teacher educators and numeracy coordinators within the training cohorts ensured that school leadership actors were directly engaged in both learning and implementation processes. This

vertical alignment fostered school environments that were more conducive to sustained pedagogical change.

Emerging teacher-leaders also began assuming mentoring roles within their schools, modelling effective practices and supporting colleagues in lesson planning and instructional problem-solving. Several schools reported the initiation of 'cascading' PD activities led by ACT participants, effectively multiplying the reach of the programme's initial cohort. Such distributed leadership reflects research highlighting the importance of building internal PD capacity to reduce over-reliance on external expertise (Loucks-Horsley et al., 2010). As Ministries of Education observed, these developments signal the emergence of more self-sustaining PD systems that can adapt and evolve beyond the life of the initial intervention.

The three excerpts that follow are posts in different Moodle forums of some of the participant-leaders.

Teacher Educator

> Recently, I introduced the concept of fractions to my pre-service teachers using the Concrete-Pictorial-Abstract (CPA) approach to explore unit fractions. This method enabled students to investigate and discover various properties of unit fractions through hands-on activities and reasoning. The majority of students were impressed by this approach, highlighting its effectiveness in enhancing their critical thinking and overall understanding. This experience reinforced the importance of the CPA framework in promoting deeper mathematical comprehension and engagement. However, a key challenge we encountered was the limited availability of manipulatives, preventing each teacher from having individual access to hands-on materials.

Numeracy Coach

> As a numeracy coach with two schools, I immediately went back to one of the schools and found their fraction tiles. I put them in order and shared with the grade 5 teacher who had also attended the workshop. She immediately started using the tiles in her fraction lessons. Since that time, I have observed the grade 4 teachers at that school who just started with fractions. I had to remind them that the school does have fraction tiles as they had not used them as yet. I do think they needed to have an opportunity to use the tiles themselves before they would feel comfortable using them in class.
>
> In my second school, they did not have any fraction tiles. I made 18 sets of tiles out of bristol board and put them in sandwich baggies. I was able to hold a workshop on Fraction Manipulatives in this school on March 6. The grade 5 teacher was still hesitant to use them, but I said I would sit in and help. He used my slides from my workshop, many of which were based on the ACT workshop. I encouraged him to just let the students play with the tiles and sort them for some time. At the end of the class, the teacher was amazed at how quickly the time went by. He now regularly uses the tiles and also frequently draws pictures of the tiles on the board. In fact, the other day a third grade teacher was trying to use the fraction tiles and the 5th grade teacher had them checked out. I did discuss with him that other teachers should be able to access the tiles when they need them.

Principal

> This course was a real eye opener for me and forced me to engage in much introspection. It brought me back to my days as a classroom teacher and realized how much my lessons could have been enhanced. The face to face session on fractions really set the tone for a very engaging and interactive six months. The correct use of the CPA approach, the plethora of virtual manipulatives that were made accessible and the very well detailed problem solving resource booklet will definitely be worthwhile assets in our efforts to enhance Mathematics learning and instruction in our districts.

Theoretical, Empirical, and Practical Contributions

The ACT in Mathematics Project makes notable theoretical, empirical, and practical contributions to teacher professional development in small, under-resourced education systems.

Theoretical Contributions

The ACT model advances PD theory by blending sustained, practice-based learning with teacher agency, reflection, and identity. Rooted in Clarke and Hollingsworth's framework, it translates global PD principles into a locally responsive design. Rather than focusing solely on skill acquisition, the model fosters transformative learning, enabling teachers to unlearn

misconceptions, apply new strategies, and adapt within real-world constraints such as time, funding, and digital access.

Key elements include a six-month timeline, deep focus on fractions and problem-solving, embedded practice, feedback from multiple sources, mindset development, and a flexible blended format. These contribute to a richer understanding of effective PD through coherence, adaptability, and trust.

Empirical Contributions

Using a mixed-methods, developmental evaluation, the project collected data through surveys, artefacts, reflections, and supervisor feedback. Unlike studies based only on self-reports, ACT included evidence of classroom application and third-party validation, offering a fuller picture of teacher learning.

Results show that context-sensitive, blended PD can improve teacher knowledge, confidence, and pedagogy even in low-resource settings. Participants adapted strategies to local curricula and learner needs, strengthening the empirical case for flexible, high-impact PD.

Practical Contributions

The ACT model presents a replicable, scalable PD approach suited to small-island contexts. Its structure balanced flexibility with depth, supporting sustained engagement through face-to-face workshops, virtual sessions, and Communities of Practice.

It addressed persistent challenges such as fragmented PD and lack of follow-up by promoting application, collaboration, and leadership. Early signs of replication and continued teacher-led initiatives indicate potential for broader adoption across the region.

Limitations

Despite its strengths, the study has several limitations. It relied largely on self-reported data, supplemented by artefacts and supervisor feedback, but lacked direct classroom observations and student achievement data to confirm instructional impact. Engagement with online components varied, with some participants contributing minimally, which may have affected the consistency of learning experiences. Additionally, the volume of forum-based tasks proved challenging for some teachers balancing full-time workloads. Lastly, while implementation across three countries enriched the study, contextual differences may limit the generalisability of findings without adaptation.

Implications

The experience of the ACT in Mathematics Project affirms that future professional development for mathematics teachers in small states must be locally anchored and nationally institutionalised to ensure relevance and sustainability. While externally supported interventions such as ACT can catalyse instructional improvement, lasting impact depends on embedding professional learning within the formal structures of teacher certification, career progression, and ongoing school-

based support. Ministries of Education, teacher training institutions, and school leadership teams must coordinate to formalise Communities of Practice, strengthen mentoring models, and align PD participation with professional advancement pathways. In doing so, PD ceases to function as a series of disconnected workshops and instead becomes an integrated dimension of teachers' professional growth trajectories, responsive to national development priorities and contextual realities.

Equally, the findings highlight that professional development must cultivate both instructional adaptability and digital pedagogical fluency if mathematics teachers are to meet the evolving demands of their classrooms. While ACT succeeded in building participants' initial confidence with TEL platforms and ODL environments, future PD designs must go beyond technical competence to nurture teachers' capacity for flexible pedagogical decision-making. As technology tools and student learning profiles continue to diversify, teachers require opportunities to critically evaluate and customise digital resources, integrate gender-responsive strategies, and apply differentiated approaches suited to diverse learners. This adaptive expertise enables teachers to maintain instructional rigour while responding to complex and shifting classroom contexts, making PD not merely about acquiring tools but about deepening professional judgement.

Finally, sustainable PD demands system-wide leadership coherence to reinforce and scale the instructional shifts emerging from teacher learning. The ACT experience underscores the importance of engaging school principals, curriculum officers, and ministry-level decision-makers not only as facilitators of PD but as active participants in the professional learning process. When leadership structures are aligned with instructional reform efforts, schools are better positioned to resource ongoing learning, monitor practice, and foster professional cultures that support sustained growth. For policymakers and educational leaders, this requires recognising leadership development as an essential complement to teacher PD, ensuring that system-level priorities, policy directives, and school-level support structures work in concert to sustain classroom-level instructional improvements over time.

Recommendations

In light of the above findings and implications, several targeted recommendations are offered to guide policy formulation, institutional strengthening, and the long-term evolution of professional development systems for mathematics teachers in small states.

National teacher education frameworks should embed hybrid PD models that combine synchronous engagement, asynchronous flexibility, and structured practice-based learning. This integrated approach allows teachers to balance the realities of full-time teaching with ongoing professional learning, while also fostering collaborative problem-solving and reflective inquiry as central components of teacher growth.

PD systems should formalise micro-credentialling pathways that recognise and reward specialised teacher competencies in areas such as mathematics content knowledge, digital pedagogy, and gender-responsive instruction. Micro-credentials offer a flexible, stackable

certification model that aligns teacher learning with career progression, while also providing ministries with tangible metrics for monitoring system-wide capacity development.

National education authorities and regional partners should deepen collaboration through established mechanisms such as the Virtual University for Small States of the Commonwealth (VUSSC). VUSSC provides a valuable platform for cross-country knowledge exchange, research dissemination, and joint capacity building, particularly relevant for small states that share common structural, geographic, and economic challenges in sustaining PD provision.

Finally, all PD reform efforts must intentionally position mathematics teacher development within national STEM workforce strategies. Strengthening mathematics teaching is not only a pedagogical imperative but a critical pillar for expanding STEM-readiness and driving long-term economic competitiveness. As global industries increasingly demand numeracy, problem-solving, and data analysis competencies, investment in mathematics teacher PD becomes directly tied to the region's future human capital resilience.

Conclusion

The ACT in Mathematics Project has demonstrated that sustained, well-structured professional development can meaningfully transform mathematics teaching in small island states. The hybrid, ODL-enabled approach, rooted in sound theoretical models and adapted to local contexts, enabled teachers to deepen their content knowledge, refine pedagogical practices, and engage with new technologies in ways that extend beyond their immediate classrooms. At the same time, the project illustrated that effective PD must be viewed as part of a wider system of leadership development, institutional coherence, and regional cooperation.

As education systems across the Caribbean continue to confront both persistent learning challenges and emerging STEM-driven economic demands, the lessons of ACT offer a valuable roadmap for building more resilient, adaptable, and scalable PD systems. The next phase must focus on institutionalising these gains: embedding hybrid PD structures within national policy, scaling micro-credentialling frameworks, expanding digital infrastructure, and training national facilitators who can sustain local expertise. With deliberate leadership and sustained commitment, professional development can move from being episodic to becoming the core engine for building an agile, future-ready teaching workforce that supports both educational equity and national development priorities.

References

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education, 59*(5), 389–407. https://doi.org/10.1177/0022487108324554

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Burunciuc, L. (2025). Educational performance trends in the OECS. *Caribbean Development Review*. [Note: This is treated as a placeholder, pending publication verification.]

Cai, J., Morris, A., Hohensee, C., Hwang, S., Robison, V., & Hiebert, J. (2019). Clarifying mathematical conceptual understanding: A focus on representation and reasoning. *Educational Studies in Mathematics, 102*, 1–20. https://doi.org/10.1007/s10649-019-09884-8

Carrillo, J., Climent, N., Contreras, L. C., & Muñoz-Catalán, M. C. (2018). The mathematics teacher's specialised knowledge (MTSK) model. In T. Leuders, J. Leuders & K. Philipp (Eds.), *Exploring the mathematics teacher's professional knowledge* (pp. 9–31). Springer. https://doi.org/10.1007/978-3-319-96881-0_2

Chapman, O. (2013). Investigating mathematics teacher knowledge for teaching problem solving. *Journal of Mathematics Teacher Education, 16*(4), 257–284. https://doi.org/10.1007/s10857-013-9233-7

Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education, 18*(8), 947–967. https://doi.org/10.1016/S0742-051X(02)00053-7

Commonwealth of Learning (COL). (2020). *Guidelines on distance education during COVID-19*. COL. https://www.col.org

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). *Effective teacher professional development*. Learning Policy Institute. https://learningpolicyinstitute.org/product/teacher-prof-dev

Farrell, G., & Oliveira, J. (Eds.). (2008). *Open educational resources: Lessons from open and distance learning*. Commonwealth of Learning.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? *American Educational Research Journal, 38*(4), 915–945. https://doi.org/10.3102/00028312038004915

Hecht, S. A., & Vagi, K. J. (2012). Sources of group and individual differences in emerging fraction skills. *Journal of Educational Psychology, 104*(4), 843–860. https://doi.org/10.1037/a0028680

Lindberg, S. M., Hyde, J. S., Petersen, J. L., & Linn, M. C. (2010). New trends in gender and mathematics performance: A meta-analysis. *Psychological Bulletin, 136*(6), 1123–1135. https://doi.org/10.1037/a0021276

Loucks-Horsley, S., Stiles, K. E., Mundry, S., Love, N., & Hewson, P. W. (2010). *Designing professional development for teachers of science and mathematics* (3rd ed.). Corwin Press.

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2014). The effectiveness of online and blended learning: A meta-analysis of the empirical literature. *Teachers College Record, 115*(3), 1–47. https://doi.org/10.1177/016146811311500307

OECD. (2018). *Equity in education: Breaking down barriers to social mobility*. OECD Publishing. https://doi.org/10.1787/9789264073234-en

The Organisation of Eastern Caribbean States. (2012). *2012-2021 OECS education sector strategy*. OECS. https://www.globalpartnership.org/sites/default/files/2012-2021-oecs-education-sector-strategy_0.pdf

Patton, M. Q. (2010). *Developmental evaluation: Applying complexity concepts to enhance innovation and use*. Guilford Press.

Piñeiro, J. L., Chapman, O., Castro-Rodríguez, E., & Castro, E. (2024, 2024/09/13). Prospective primary teachers' initial mathematical problem-solving knowledge. *International Journal of Mathematical Education in Science and Technology, 55*(8), 1914-1937. https://doi.org/10.1080/0020739X.2022.2107958

Siegler, R. S., Thompson, C. A., & Schneider, M. (2010). An integrated theory of whole number and fractions development. *Cognitive Psychology, 62*(4), 273–296. https://doi.org/10.1016/j.cogpsych.2011.03.001

Sims, S., Fletcher-Wood, H., O'Mara-Eves, A., Cottingham, S., Stansfield, C., Goodrich, J., Van Herwegen, J., & Anders, J. (2025). Effective teacher professional development: New theory and a meta-analytic test. *Review of Educational Research, 95*(2), 213-254. https://doi.org/10.3102/00346543231217480

Small, L. (2024). Regional mathematics performance: A review of OECS assessments. *Caribbean Journal of Education Research*. [Note: Placeholder for regionally referenced work.]

UNESCO. (2015). *Education 2030: Incheon Declaration and Framework for Action—Towards inclusive and equitable quality education and lifelong learning for all*. UNESCO.

Unterhalter, E. (2017). *Gender equality in education: A review of trends and factors*. UNESCO.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge University Press.

Winheller, S., Kunina-Habenicht, O., & Hardy, I. (2013). The role of content knowledge and pedagogical content knowledge in mathematics instruction: A theoretical model. *Journal of Educational Psychology, 105*(3), 632–640. https://doi.org/10.1037/a0031957

World Bank. (2020). *World development report 2020: Trading for development in the age of global value chains*. World Bank. https://www.worldbank.org/en/publication/wdr2020