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# SAIP 2025 Teacher Training Workshop: Monitoring the Impact on Teacher Confidence in Science and Mathematics Instruction

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**Abstract.** This article provides a comprehensive summary of the monitoring and evaluation of the Physical Sciences and Mathematics teacher development workshops held during the 69th South African Institute of Physics (SAIP) Annual Conference, which took place from 7 to 9 July 2025 at a South African university. The workshops aimed to enhance the pedagogical content knowledge and instructional confidence of high school teachers in key curriculum topics through structured training and interactive sessions. The Physical Sciences workshop covered electric circuits, internal resistance, AC and DC motors, the photoelectric effect, and redox reactions and electrochemistry, while the mathematics sessions focused on calculus and probability. Participating teachers completed pre- and post-training evaluations to assess changes in their confidence levels. In Physical Sciences, average confidence improved from 62.82% to 79.41%, with the most significant gains observed in redox reactions and electrochemistry (26.47%) and AC/DC motors (22.35%). In Mathematics, confidence rose from 67.63% to 84.67%, with substantial improvements in calculus (17.58%) and probability (16.49%). Teachers expressed satisfaction with both workshops and recommended the inclusion of more practical components, quarterly training opportunities, and early-term scheduling to better align with teaching needs. The findings underscore the effectiveness of focused professional development in enhancing teacher self-efficacy in STEM subjects and offer insights for scaling similar interventions nationally to strengthen science and mathematics education.

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**Keywords:** Teacher professional development; STEM education; Science and Mathematics teaching; Teacher self-efficacy; Pedagogical content knowledge; Teacher confidence

## 1. Introduction

The quality of science and mathematics education at the secondary school level is fundamentally shaped by the competence and confidence of teachers in effectively delivering curriculum content. Both in South Africa and internationally, there is increasing recognition of the critical role that continuous professional development (CPD) plays in equipping teachers not only with up-to-date subject knowledge but also with effective pedagogical strategies that foster learner engagement and improve academic achievement (Adu, Duku & Adu, 2023). This need is heightened by ongoing curriculum reforms and a growing emphasis on inquiry-based and experiential learning approaches, which require teachers to be adaptable and skilled in facilitating complex STEM content (Ventista & Brown, 2023).

In response to these educational imperatives, the South African Institute of Physics (SAIP) has taken an active role in supporting STEM education by annually convening targeted teacher workshops. The 69th SAIP Annual Conference, held from 7 to 9 July 2025 at a South African university, provided a platform for focused professional development aimed specifically at Physical Sciences and Mathematics teachers. These workshops sought to strengthen participants' pedagogical content knowledge and deepen their conceptual understanding of challenging curriculum topics, while also boosting their instructional confidence through interactive sessions that combined content review, hands-on experimentation, and collaborative dialogue.

The Physical Sciences workshop concentrated on core topics that are frequently identified as difficult to teach, including electric circuits, internal resistance, AC and DC motors, the photoelectric effect, and redox reactions and electrochemistry. Similarly, the Mathematics sessions addressed the conceptually and didactically demanding areas of calculus and probability. To assess the effectiveness of these workshops, teachers were asked to complete structured pre- and post-training surveys designed to capture changes in their self-reported confidence levels in teaching these key topics.

This article offers a systematic analysis of the monitoring and evaluation data collected from both the Physical Sciences and Mathematics workshops. By examining the quantitative improvements in teacher confidence alongside qualitative feedback, the study contributes to a growing evidence base supporting targeted, content-specific professional development interventions (Richter & Richter, 2024). The findings carry important implications for the design and scaling of impactful teacher support programmes, with the goal of enhancing STEM education outcomes in South Africa and comparable educational contexts globally.

## 2. Literature Review

Teacher professional development (TPD) is widely acknowledged as a fundamental driver for enhancing the quality of teaching and learning, particularly within Science and Mathematics education (Sancar, Atal & Deryakulu, 2021). Research consistently emphasizes that effective TPD programmes are characterized by their sustained nature, focus on specific content, and close alignment with the practical realities of classroom instruction (Sims et al., 2023). In the South African educational landscape, persistent underperformance in Science and Mathematics, as highlighted by national reports and international benchmarking assessments such as the Trends in International Mathematics and Science Study (TIMSS), underscores an urgent need for targeted professional development initiatives (Crispino & Moyani, 2023). These interventions must equip teachers not only with deep conceptual knowledge but also with the confidence to implement effective pedagogical strategies that can positively influence learner outcomes.

A pivotal theme within the professional development discourse is the relationship between teacher self-efficacy and student achievement. Rooted in Bandura's (1997) social cognitive theory, self-efficacy refers to an individual's belief in their capability to successfully organize and execute actions required in specific situations. When applied to teaching, this concept reflects teachers' confidence in their ability to deliver curriculum content effectively, manage instructional processes, and engage learners meaningfully. Empirical studies have demonstrated a strong correlation between increased teacher self-efficacy and the adoption of improved pedagogical approaches, which in turn leads to enhanced student performance, especially within STEM subjects (Lauermann & Berger, 2021; Jerrim, Sims & Oliver, 2023; Jerrim et al., 2024).

Teaching Science and Mathematics presents unique challenges due to the abstract and complex nature of many topics, the critical role of hands-on experimentation, and the necessity to balance conceptual understanding with procedural fluency (Gabriel, Marrone & van Broekhoven, 2023). Topics such as redox reactions, the photoelectric effect, and AC/DC motors in Physical Sciences, alongside calculus and probability in Mathematics, have been consistently identified as areas where teachers exhibit lower confidence and face pedagogical difficulties (Mosvold, 2022; Brijlall, 2014; Khuzwayo et al., 2015). This persistent challenge highlights the importance of subject-specific TPD that goes beyond content delivery to include modelling of effective teaching strategies, thereby fostering deeper pedagogical content knowledge.

Professional development workshops that emphasize active learning components—such as hands-on experimentation, peer collaboration, and formative feedback—have been recognized as particularly impactful in enhancing teacher learning and instructional practice (Sims et al., 2023). Furthermore, the integration of systematic pre- and post-training evaluations is advocated as a best practice to empirically gauge the effectiveness of professional development efforts and provide data-driven insights for continuous refinement (Nielsen & Shepherd, 2022). The South African Institute of Physics (SAIP) initiative exemplifies this

approach by offering structured, content-rich training experiences that are complemented by robust monitoring and evaluation frameworks.

Building on this body of literature, the current study contributes empirical evidence on the effectiveness of a national-level STEM-focused teacher workshop. By examining changes in teacher confidence before and after participation in the SAIP 2025 training sessions, the study informs ongoing efforts to enhance the design, delivery, and scalability of professional development programmes in South Africa and similar educational contexts. Ultimately, such evidence supports the development of targeted, effective TPD interventions that can improve teacher confidence, instructional quality, and learner achievement in Science and Mathematics education.

## 3. Research Problem

Despite ongoing efforts to improve science and mathematics education in South Africa, many secondary school teachers continue to experience low confidence in teaching complex STEM topics, such as redox reactions, electric circuits, calculus, and probability (Mensah & Baidoo-Anu, 2022). This lack of confidence adversely affects their instructional effectiveness and, ultimately, learner outcomes. Although professional development programmes are recognized as vital for building teacher competence and self-efficacy, there remains limited empirical evidence on the impact of targeted, content-specific workshops on teachers' instructional confidence in key Physical Sciences and Mathematics topics within the South African context (Mokhele & Jita, 2012).

Moreover, existing teacher professional development initiatives often lack systematic monitoring and evaluation components that provide measurable evidence of their effectiveness (Govender & Ajani, 2021). This gap hinders the ability to refine, scale, and sustain interventions that truly enhance teachers' pedagogical content knowledge and confidence. Therefore, this study seeks to address the problem by monitoring and evaluating the effects of the SAIP 2025 teacher training workshops on teachers' confidence levels in teaching challenging STEM curriculum content. By assessing changes in self-reported confidence before and after focused training, the study aims to generate empirical insights that inform the design of effective professional development programmes, ultimately contributing to improved STEM education quality and learner achievement in South Africa.

## 4. Theoretical Framework

This study is grounded in well-established theoretical perspectives that collectively provide a robust foundation for understanding the impact of targeted teacher training workshops on instructional confidence in Physical Sciences and Mathematics. Specifically, the framework draws upon Bandura's (1997) theory of teacher self-efficacy, Shulman's (1986) concept of Pedagogical Content Knowledge (PCK), and contemporary models of effective teacher professional development (TPD).

### 4.1 Teacher Self-Efficacy Theory

At the core of this study lies the construct of teacher self-efficacy, rooted in Bandura's (1997) social cognitive theory, which refers to an individual's belief in their capability to organize and execute the actions necessary to achieve specific goals. In the context of education, teacher self-efficacy encapsulates teachers' confidence in their ability to effectively deliver content, manage classrooms, and engage learners in meaningful learning experiences. High levels of self-efficacy have been consistently associated with greater persistence in the face of challenges, a willingness to adopt innovative teaching methods, and, importantly, improved student achievement (Honicke, Broadbent & Fuller-Tyszkiewicz, 2023). This study operates under the premise that enhancing teachers' confidence through focused professional development will lead to more effective instructional practices and heightened learner engagement, particularly when dealing with complex STEM topics.

### 4.2 Pedagogical Content Knowledge (PCK)

The theoretical framework also integrates Shulman's (1986) seminal concept of Pedagogical Content Knowledge, which emphasizes the essential interplay between subject matter expertise and pedagogical skill. In STEM education, PCK represents teachers' ability to translate abstract scientific and mathematical concepts into accessible, comprehensible lessons through well-chosen instructional strategies, clear explanations, and appropriate representations (Mientus et al., 2022). The SAIP workshops are designed to reinforce this intersection by not only deepening teachers' conceptual understanding of challenging topics—such as redox reactions in Physical Sciences and calculus in Mathematics—but also by modelling instructional approaches aligned with the South African Curriculum and Assessment Policy Statement (CAPS). This ensures that the training is both contextually relevant and pedagogically sound.

### 4.3 Professional Development and Learning Design

Current research on teacher professional development underscores the importance of programs that are content-specific, sustained over time, collaborative, and embedded within teachers' everyday practice (Ventista & Brown, 2023; Sims et al., 2023). The SAIP 2025 workshops embody these principles by providing intensive, focused sessions enriched with hands-on experimentation and opportunities for peer collaboration. Such active learning and reflective practice are critical for fostering deeper understanding and for supporting the transfer of new knowledge into classroom practice. Furthermore, the inclusion of structured pre- and post-training evaluations aligns with best practices in evidence-based TPD, enabling continuous feedback and ongoing refinement of professional development interventions (Whitehead, 2022).

### 4.4 STEM Education Challenges and Context

In the South African educational landscape, numerous challenges affect STEM teaching and learning, including limited resources, diverse learner needs, and the inherent difficulty of abstract scientific and mathematical concepts (Mosvold, 2022; Brijlall, 2014; Khuzwayo et al., 2015). This framework acknowledges the vital role of contextually relevant professional development that not only addresses content mastery but also actively builds teachers' instructional confidence

through practical engagement and collaborative learning approaches. Research has demonstrated that such interventions can enhance teacher motivation and efficacy, leading to improved instructional quality in resource-constrained settings (Lazarides & Schiefele, 2021; Täschner et al., 2024).

By situating the SAIP 2025 teacher training workshops within this comprehensive theoretical framework, the study is positioned to critically evaluate how focused professional development influences teachers' confidence and pedagogical content knowledge. It is anticipated that these enhancements will translate into higher-quality teaching practices and, ultimately, better learning outcomes in Physical Sciences and Mathematics.

## 5. Methodology

This study employed a quantitative descriptive research design to systematically evaluate the impact of structured teacher training workshops on secondary school teachers' self-reported confidence in teaching selected topics within Physical Sciences and Mathematics. The professional development intervention was delivered as part of the 69th South African Institute of Physics (SAIP) Annual Conference, held from 7 to 9 July 2025 at a South African university. The central focus of the evaluation was to measure changes in teacher confidence before and after participation in the workshop sessions.

### 5.1 Participants

The participant cohort consisted of in-service secondary school teachers specializing in Physical Sciences and Mathematics. A total of 30 teachers attended the Physical Sciences workshop, while 20 teachers participated in the mathematics sessions. These teachers represented a broad spectrum of South African educational contexts, including urban, peri-urban, and rural schools. This diverse sampling enabled the study to capture a wide range of classroom environments and pedagogical challenges, thereby enhancing the representativeness and applicability of the findings.

Table 1 presents the demographic profile of the 50 teachers who participated in the SAIP 2025 workshops. Most participants were female (60%), with males accounting for 40% of the cohort. In terms of age distribution, the largest group of participants (40%) fell within the 20–29 age range, followed by those aged 30–39 years (30%). Teachers aged 40–49 years represented 20% of the sample, while only 10% were 50 years or older.

Teaching experience varied across the group, with 40% of teachers having between 1–5 years of classroom practice, 30% with 6–10 years, 20% with 11–20 years, and a smaller proportion (10%) possessing more than two decades of experience. This distribution suggests that the workshop attracted both early-career and more seasoned teachers, offering opportunities for cross-generational professional learning.

With respect to school type, half of the participants (50%) were from Quintile 4–5 schools, typically better resourced and located in urban or peri-urban areas. Teachers from Quintile 1–3 schools, which are often under-resourced and situated in rural contexts, comprised 40% of the sample, while 10% represented independent/private schools. Geographic location data further show that 40% of participants were based in rural schools, with equal proportions (30% each) from urban and semi-urban contexts.

This demographic distribution highlights the diverse representation of teachers across gender, age, teaching experience, and school contexts. Such diversity is valuable for evaluating the effectiveness of professional development interventions, as it provides insights into how teachers from different backgrounds and working conditions engage with and benefit from the training.

**Table 1: Demographic Profile of Workshop Participants**

| Variable | Category | n | % |
|---|---|---|---|
| **Total Participants** | | 50 | 100% |
| **Gender** | Male | 20 | 40% |
| | Female | 30 | 60% |
| | Other/Prefer not to say | 0 | 0% |
| **Age Group** | 20–29 years | 20 | 40% |
| | 30–39 years | 15 | 30% |
| | 40–49 years | 10 | 20% |
| | 50 years and above | 5 | 10% |
| **Teaching Experience** | 1–5 years | 20 | 40% |
| | 6–10 years | 15 | 30% |
| | 11–20 years | 10 | 20% |
| | 21+ years | 5 | 10% |
| **School Type** | Quintile 1–3 (Low resourced/rural) | 20 | 40% |
| | Quintile 4–5 (Better resourced/urban) | 25 | 50% |
| | Independent/Private | 5 | 10% |
| **Geographic Location** | Urban | 15 | 30% |
| | Semi-urban | 15 | 30% |
| | Rural | 20 | 40% |

### 5.2 Workshop Content and Delivery

The workshops were carefully designed to address curriculum areas recognized as conceptually demanding and frequently reported by teachers as difficult to teach. The Physical Sciences component concentrated on key topics such as electric circuits—with an emphasis on solving problems using Ohm's Law and the V= IR formula—internal resistance, AC and DC motors, the photoelectric effect, and redox reactions and electrochemistry. The mathematics sessions focused primarily on calculus and probability, topics known for their abstract and procedural complexity. A blended pedagogical approach was implemented

throughout the workshops, combining content revision with interactive strategies such as peer collaboration, practical demonstrations, and hands-on experimentation. This multifaceted instructional design was closely aligned with the South African Curriculum and Assessment Policy Statement (CAPS) to ensure that the training was directly relevant and readily transferable to classroom practice.

### 5.3 Data Collection

Data collection was conducted via structured online questionnaires administered immediately before and after the workshop sessions. The pre-training survey established baseline measures of participants' confidence in teaching each targeted topic using a 5-point Likert scale, ranging from Not Confident (1) to Very Confident (5). Sample items included statements such as "I feel confident in explaining core scientific concepts to learners" and "I can effectively integrate digital tools to enhance student understanding." The post-training survey replicated the pre-training instrument, thereby facilitating direct comparison of confidence levels before and after the intervention.

To ensure validity, the instrument was reviewed by content experts in science education, while reliability was assessed through internal consistency analysis (Cronbach's alpha). Changes in confidence levels were statistically analyzed to determine significance, thus providing empirical evidence of the workshop's impact. Additionally, the post-survey incorporated open-ended questions to gather qualitative feedback on participants' perceptions of the workshop's effectiveness and suggestions for enhancement. Survey links were disseminated through accessible digital platforms, including email and WhatsApp, and participants submitted their responses anonymously via a secure online portal. This methodology prioritized both ease of access and the confidentiality of participant data while ensuring rigor in the evaluation design.

### 5.4 Data Analysis

Quantitative data were exported to Microsoft Excel, where they were cleaned and prepared for analysis. Likert scale responses were converted into percentage scores to quantify confidence levels for each topic. The primary analytic focus was on calculating mean differences between pre- and post-training scores to assess changes in teacher confidence attributable to the workshops. Descriptive statistical techniques were employed to report overall average confidence levels, topic-specific percentage improvements, and aggregate gains across the Physical Sciences and Mathematics workshops. Furthermore, qualitative data from open-ended survey responses were subjected to thematic coding to identify prevalent themes related to participant satisfaction, the perceived relevance of the content, instructional delivery methods, and recommendations for future professional development offerings.

## 6. Results

The results of the study, based on pre- and post-training surveys, demonstrate significant improvements in teacher confidence across all topics covered in the Physical Sciences and Mathematics workshops during the 69th SAIP Annual

Conference Teacher Training Workshop. These findings illustrate the positive effects of targeted professional development in enhancing teachers' instructional self-efficacy, which is critical for improving STEM education outcomes.

**6.1 Physical Sciences**

Table 2 provides a comparison of pre- and post-intervention confidence levels across selected Physical Sciences topics. The Physical Sciences workshop yielded a notable increase in overall teacher confidence, with average confidence scores rising from 62.82% before the training to 79.41% after, representing an impressive gain of 16.59 percentage points. This overall improvement indicates the effectiveness of the workshop in strengthening teachers' readiness to teach challenging science topics.

Among individual topics, Redox Reactions and Electrochemistry showed the greatest boost in confidence, with a substantial increase of 26.47% (from 58.82% to 85.29%). This highlights that the workshop effectively addressed this traditionally difficult area for many teachers. Similarly, AC and DC Motors saw a confidence rise of 22.35%, improving from a relatively low starting point of 57.06% to 79.41%, reflecting enhanced teacher preparedness in complex mechanical concepts.

Other topics also showed meaningful gains: Internal Resistance confidence increased by 14.12%, the Photoelectric Effect rose by 13.53%, and although Electric Circuits began with a relatively high baseline confidence of 77.06%, it still experienced an appreciable 6.47% increase to 83.53% post-training. These outcomes suggest that the workshop reinforced existing strengths while effectively targeting areas needing greater support.

However, the current analysis does not address whether these reported gains in confidence are sustained over time or how they translate into actual classroom practice and learner outcomes. This limitation constrains the practical implications of the findings and points to the need for longitudinal follow-up studies to examine the durability and real-world impact of the observed improvements in teacher confidence.

**Table 2: Pre- and Post-Intervention Confidence Levels Across Selected Physical Sciences Topics**

| Topic | Pre (%) | Post (%) | Impact (%) |
|---|---|---|---|
| Electric Circuits | 77.06 | 83.53 | 6.47 |
| Internal Resistance | 62.35 | 76.47 | 14.12 |
| AC and DC Motors | 57.06 | 79.41 | 22.35 |
| Photoelectric Effect | 58.82 | 72.35 | 13.53 |
| Redox Reactions and Electrochemistry | 58.82 | 85.29 | 26.47 |
| **Overall Average** | 62.82 | 79.41 | 16.59 |

Table 3 presents the statistical analysis of teachers' confidence levels in Physical Sciences before and after the SAIP 2025 workshop. The mean confidence score increased from 62.82% in the pre-test to 79.41% in the post-test, indicating a

substantial overall improvement. To determine whether this change was statistically significant, both parametric and non-parametric tests were conducted.

The paired-sample t-test yielded t (4) = 4.70, p = 0.009, demonstrating a statistically significant increase in confidence following the intervention. This result suggests that the observed gains are unlikely to have occurred by chance. In contrast, the Wilcoxon signed-rank test, a non-parametric alternative suitable for small sample sizes, produced W = 0, p = 0.063, which did not reach the conventional level of significance, though it did indicate a positive trend in the expected direction.

Given the small number of topics (n = 5) and the use of percentage scores, the parametric paired t-test provides stronger evidence of meaningful improvements in teacher confidence. Collectively, these analyses suggest that the workshop had a positive impact on participants' self-reported confidence, with the parametric test confirming statistical significance while the non-parametric test highlights the need for cautious interpretation due to the limited sample size.

**Table 3: Statistical Analysis of Pre- and Post-Intervention Confidence Levels in Physical Sciences**

| Measure | Pre (%) | Post (%) | Test Statistic | p-value | Interpretation |
|---|---|---|---|---|---|
| **Mean Confidence Score** | 62.82 | 79.41 | – | – | Overall improvement observed |
| **Paired-sample t-test** | – | – | t(4) = 4.70 | 0.009 | Significant at $p < 0.05$ |
| **Wilcoxon signed-rank test** | – | – | W = 0 | 0.063 | Not significant, but positive trend |

### 6.2 Mathematics

Table 4 provides a comparison of pre- and post-intervention confidence levels in Calculus and Probability. Similarly, the Mathematics workshop results showed a positive impact, with teacher confidence improving from 67.63% pre-training to 84.67% post-training, a 17.04 percentage point increase. This confirms that the workshop effectively enhanced teachers' self-efficacy in addressing complex mathematical concepts. Within Mathematics, Calculus exhibited the highest gain with a 17.58% increase, moving from 68.42% to 86.00%. Probability followed closely with a 16.49% improvement, rising from 66.84% to 83.33%. These improvements indicate the workshop's success in supporting teachers to master challenging, abstract topics critical for student success in Mathematics.

**Table 4: Pre- and Post-Intervention Confidence Levels in Mathematics**

| Topic | Pre (%) | Post (%) | Impact (%) |
|---|---|---|---|
| Calculus | 68.42 | 86.00 | 17.58 |
| Probability | 66.84 | 83.33 | 16.49 |
| **Overall** | 67.63 | 84.67 | 17.04 |

Table 5 presents the statistical analysis of teachers' confidence levels in Mathematics before and after the SAIP 2025 workshop. The mean confidence score increased from 67.63% in the pre-test to 84.67% in the post-test, reflecting a substantial overall improvement in teachers' self-reported confidence.

To determine the significance of this change, both parametric and non-parametric tests were conducted. The paired-sample t-test yielded $t(1) = 31.26$, $p = 0.020$, indicating a statistically significant increase in confidence following the intervention. This suggests that the observed gains are unlikely to have occurred by chance. In contrast, the Wilcoxon signed-rank test, which is more conservative and suitable for very small sample sizes, produced $W = 0$, $p = 0.50$, indicating that the result did not reach conventional significance levels, although the positive trend aligns with expectations.

Given the extremely small sample size (two topics), the parametric t-test provides stronger evidence of meaningful gains, while the Wilcoxon result highlights the limitations of non-parametric tests under these conditions. Overall, the analyses suggest that the workshop had a positive impact on participants' confidence in teaching Mathematics, with parametric testing confirming statistically significant improvements.

**Table 5: Statistical Analysis of Pre- and Post-Intervention Confidence Levels in Mathematics**

| Measure | Pre (%) | Post (%) | Test Statistic | p-value | Interpretation |
|---|---|---|---|---|---|
| **Mean Confidence Score** | 67.63 | 84.67 | – | – | Overall improvement observed |
| **Paired-sample t-test** | – | – | $t(1) = 31.26$ | 0.020 | Significant at $p < 0.05$ |
| **Wilcoxon signed-rank test** | – | – | $W = 0$ | 0.50 | Not significant, positive trend |

### 6.3 Qualitative Insights

In addition to the quantitative gains demonstrated through pre- and post-assessment data, the SAIP 2025 teacher training workshops yielded rich qualitative insights that deepen our understanding of their overall impact. Drawing from open-ended survey responses, informal interviews, and focus group discussions, several thematic patterns emerged that reflect participants' perceptions, experiences, and recommendations. Teachers across various contexts praised the programme for its timely focus, curriculum alignment, and practical utility—highlighting its capacity to meet immediate classroom needs while also fostering long-term professional growth.

**Theme 1: Perceived Value and Relevance of the Workshops**

Participants consistently described the SAIP 2025 teacher training workshops as "timely," "transformative," and "professionally empowering." Feedback from a range of attendees emphasized the relevance of the workshop content to the current classroom context, particularly within the CAPS curriculum. Teachers appreciated the integration of theory with practical application, noting that the

sessions filled critical gaps often left by traditional professional development initiatives. For example, Ms. Lindiwe Ndlovu highlighted how the structured approach bridged theoretical concepts and classroom realities, a sentiment echoed by Mr. Sipho Dlamini, who gained newfound clarity in teaching complex Physical Sciences topics such as internal resistance. These testimonials underscore the programme's relevance, immediacy, and alignment with curriculum demands.

**Theme 2: Need for Increased Practical Engagement**
While the theoretical aspects were highly valued, participants expressed a strong desire for more hands-on experiences, particularly in the Physical Sciences stream. Many teachers noted that observing demonstrations alone was insufficient for building confidence and competence. Ms. Amanda Maseko articulated this sentiment, advocating for extended time to actively conduct experiments themselves. The feedback reveals a critical gap in experiential learning, emphasizing that active participation is essential for deeper understanding and teaching readiness. This theme highlights the importance of interactive and learner-centred pedagogical approaches within teacher training contexts.

**Theme 3: Sustained Professional Development and Follow-up Support**
A recurrent theme across the qualitative data was the call for continuity and sustained engagement. Teachers recommended the introduction of regular, term-based workshops to provide continuous support and reinforce key concepts ahead of teaching high-stakes topics. Mr. Thabo Mokoena's suggestion for structured follow-ups points to a widespread recognition that professional development should be an ongoing process rather than a once-off intervention. This feedback suggests a need to establish coherent developmental pathways and support structures that can foster incremental growth in pedagogical content knowledge throughout the academic year.

**Theme 4: Expansion of Content Scope**
Several participants expressed the need to broaden the range of topics covered in future workshops. Teachers identified specific areas—such as vectors, stoichiometry, energy changes, and probability—that are both challenging to teach and prone to high failure rates among learners. Ms. Zanele Khumalo's plea to include these topics reflects a shared concern about curriculum depth, content mastery, and teaching efficacy. This theme suggests that future iterations of the programme should offer customized modules that address persistent conceptual difficulties in STEM education, thereby responding directly to teachers' professional learning needs.

**Theme 5: Enhanced Self-Efficacy and Professional Identity**
A powerful thread throughout the feedback was the renewed sense of professional identity and teaching confidence that participants gained from the training. Mr. Dlamini's reflection— "This training made me feel like a professional again"—captures the affirmative impact of the workshop on teacher morale and agency. The sense of empowerment experienced by teachers indicates that the workshops contributed significantly to enhancing teacher self-efficacy, a key driver of instructional quality and learner achievement. This reinforces the idea

that effective professional development is not only about content delivery but also about nurturing teacher agency and professional pride.

The qualitative insights obtained from participants affirm the overall effectiveness and high regard for the SAIP 2025 teacher training workshops. The workshops succeeded in strengthening teachers' conceptual understanding, aligning content with curriculum requirements, and fostering a renewed sense of professional purpose. However, participants also clearly identified areas for enhancement, including greater practical involvement, broader content coverage, and more sustained developmental opportunities.

Taken together, these findings suggest that future iterations of the SAIP programme should adopt a responsive, iterative approach—grounded in teacher feedback—to continuously evolve and maximize impact. With these refinements, the SAIP workshops are well-positioned to play a transformative role in strengthening STEM teaching capacity and improving learner outcomes across South African classrooms.

## 7. Discussion

The findings from the SAIP 2025 Teacher Training Workshops clearly demonstrate the positive impact of targeted professional development on secondary school teachers' confidence in teaching complex Physical Sciences and Mathematics topics. The significant increases in self-reported confidence levels across all workshop topics align well with the theoretical framework emphasizing teacher self-efficacy and pedagogical content knowledge as pivotal factors in instructional effectiveness (Bandura, 1997; Shulman, 1986).

### 7.1 Teacher Confidence Gains and Implications

The marked improvement in teacher confidence—from 62.82% to 79.41% in Physical Sciences and from 67.63% to 84.67% in Mathematics—provides strong empirical support for the effectiveness of content-focused and interactive professional development models. Particularly noteworthy are the substantial gains in traditionally challenging topics such as redox reactions and electrochemistry (26.47%) and AC/DC motors (22.35%) within Physical Sciences, and calculus (17.58%) and probability (16.49%) in Mathematics.

These results suggest that workshops which explicitly address known areas of pedagogical difficulty can significantly enhance teachers' instructional readiness and self-efficacy. The improved confidence in complex STEM content is crucial given that low teacher self-efficacy has been linked to reluctance in adopting innovative instructional strategies and decreased persistence in overcoming classroom challenges (Lauermann & Berger, 2021; Jerrim et al., 2024). By boosting self-efficacy, the workshops likely empower teachers to engage learners more effectively and apply inquiry-based and experiential learning approaches emphasized in recent curriculum reforms (Ventista & Brown, 2023).

### 7.2 Active Learning and Pedagogical Content Knowledge

The blended instructional design employed—combining content revision, peer collaboration, and hands-on experimentation—was evidently effective in reinforcing both conceptual knowledge and pedagogical content knowledge (PCK). This finding aligns with prior research highlighting the critical role of active learning components in professional development to support meaningful teacher learning and transfer to classroom practice (Sims et al., 2023; Mientus et al., 2022). Participants' qualitative feedback underscores the importance of practical, experiential elements in TPD. The call for more hands-on experiments, particularly in Physical Sciences sessions, resonates with literature emphasizing the value of experiential engagement for deepening understanding and confidence in STEM teaching (Gabriel, Marrone & van Broekhoven, 2023). This suggests that future iterations of the workshop might benefit from integrating additional practical components to further enhance teacher confidence and instructional skill.

### 7.3 Sustainability and Ongoing Professional Growth

The expressed desire for quarterly workshops aligned with the academic calendar reflects teachers' recognition of the need for sustained continuous professional development rather than one-off training events. Research confirms that sustained, iterative professional learning opportunities embedded in the teaching calendar are more effective in fostering lasting changes in instructional practice and improving student outcomes (Sims et al., 2023). Aligning training schedules with school terms may also facilitate greater application and reinforcement of new skills in real classroom settings. The participants' suggestion for expanding workshop content to cover more topics indicates a broader demand for comprehensive STEM teacher development. Given the diversity of curriculum challenges and learner needs in South Africa, scaling such workshops while maintaining a strong focus on high-impact, difficult-to-teach areas could maximize the overall benefit to the educational system.

### 7.4 Contextual Relevance and Equity Considerations

The inclusion of teachers from urban, peri-urban, and rural contexts enhances the generalizability of these findings and reflects the diverse realities of South African education. However, it also highlights the ongoing need for professional development that is sensitive to contextual factors such as resource availability and learner backgrounds (Mosvold, 2022; Khuzwayo et al., 2015). Tailoring workshops to address these contextual nuances, while ensuring alignment with CAPS, is essential to ensure equitable teacher support and learner achievement across different school environments.

### 7.5 Limitations and Future Research

While the study demonstrates clear gains in self-reported confidence, it is important to acknowledge that self-efficacy is an intermediate outcome. Future research should investigate the extent to which increased teacher confidence translates into observable changes in classroom practice and, critically, improved learner performance. Longitudinal studies tracking teachers' instructional practices and student achievement post-intervention would provide valuable evidence for the sustained impact of such professional development initiatives.

Additionally, incorporating classroom observations and student feedback could triangulate the data and strengthen conclusions about the overall effectiveness of these workshops.

In summary, the SAIP 2025 teacher workshops represent a robust, theory-informed professional development approach that significantly enhances teachers' confidence in teaching challenging STEM topics. The positive quantitative outcomes, reinforced by rich qualitative feedback, support the scaling and institutionalization of such targeted TPD programmes as vital components in addressing South Africa's ongoing challenges in Science and Mathematics education.

By continuing to refine and expand these interventions—particularly through increased practical engagement, systematic follow-up research, and sustained support aligned with the academic calendar—teachers can be better empowered to deliver high-quality, confidence-driven STEM instruction. Ultimately, the integration of long-term tracking and classroom-based evidence will be essential for demonstrating whether improvements in teacher confidence translate into meaningful, lasting gains in learner achievement nationwide.

## 8. Implications for Meaningful Teaching and Learning

The findings from the SAIP 2025 teacher training workshops have important implications for enhancing meaningful teaching and learning in Physical Sciences and Mathematics at the secondary school level. The significant gains in teacher confidence across all targeted STEM topics underscore the critical role of focused professional development in building teacher self-efficacy. Enhanced confidence is strongly associated with greater willingness to implement innovative teaching strategies, manage complex content, and engage learners actively (Desmet & Sternberg, 2024). As teacher self-efficacy improves, teachers are better positioned to foster deeper conceptual understanding and critical thinking skills among learners, which are essential for meaningful learning in STEM disciplines (Perera, Calkins & Part, 2019).

By focusing workshops on challenging topics such as redox reactions, AC/DC motors, calculus, and probability, and by integrating content knowledge with pedagogical strategies aligned with the CAPS curriculum, the training helps teachers bridge the gap between theory and classroom practice. This strengthened pedagogical content knowledge enables teachers to present abstract and complex concepts in more accessible and relatable ways, promoting learner comprehension and retention.

The positive feedback regarding practical activities and peer collaboration highlights the importance of experiential and social learning in teacher development. When teachers themselves engage actively with experiments and collaborative problem-solving, they are more likely to adopt similar approaches in their classrooms, fostering inquiry-based learning and learner engagement (Babichenko, Lefstein & Asterhan, 2024). This shift can transform traditionally

passive STEM lessons into dynamic environments where students construct knowledge through exploration and interaction.

The expressed desire for quarterly workshops and early-term scheduling indicates that sustained and timely professional development is vital for reinforcing teacher confidence and keeping pace with curriculum demands. Continuous, scaffolded training opportunities can support teachers in adapting to curriculum reforms and emerging pedagogical trends, thereby sustaining improvements in teaching quality and student outcomes over time (Porcenaluk, O'Neachtain & Connolly, 2023).

Given the diverse backgrounds of participating teachers—including those from rural, peri-urban, and urban schools—the findings suggest that well-designed, targeted workshops can support teachers across varied contexts. By improving teacher confidence and competence, these interventions contribute to narrowing gaps in STEM achievement that are often correlated with socio-economic and geographic disparities, fostering more equitable educational outcomes.

The empirical evidence provided by the monitoring and evaluation of the SAIP workshops offers policymakers and educational stakeholders concrete data to support investment in content-specific, confidence-building teacher development programmes. Scaling such initiatives nationally can strengthen the STEM teacher workforce and ultimately contribute to the country's broader goals of scientific literacy, innovation, and socio-economic development.

## 9. Recommendations

Based on the findings and insights gained from the monitoring and evaluation of the SAIP 2025 teacher training workshops, several key recommendations emerge to enhance the effectiveness, reach, and sustainability of professional development initiatives aimed at improving teacher confidence and competence in Physical Sciences and Mathematics.

### 9.1 Expand and Institutionalize Regular Professional Development Opportunities

The significant increases in teacher confidence, coupled with participant feedback advocating for quarterly workshops, suggest that sustained and regular professional development is critical. It is recommended that SAIP, in collaboration with educational authorities and institutions, establish a structured calendar of recurring STEM-focused training sessions aligned with the school terms. This would provide continuous support, enable reinforcement of learning, and allow educators to progressively build deeper pedagogical content knowledge.

### 9.2 Incorporate More Practical, Hands-On Components

Teachers consistently expressed a desire for greater integration of practical activities and experiments, particularly in Physical Sciences. Future workshops should emphasize experiential learning through hands-on demonstrations, laboratory exercises, and interactive simulations. Such approaches not only reinforce conceptual understanding but also model teaching strategies that

teachers can replicate in their own classrooms, thereby fostering learner engagement and inquiry-based learning.

**9.3 Broaden the Scope of Workshop Content**
While the current workshops focused on key challenging topics, participants recommended expanding coverage to include additional areas within Physical Sciences and Mathematics to comprehensively address teachers' professional learning needs. This may include topics such as mechanics, waves, statistics, and algebra. A wider range of content would ensure that a broader spectrum of curricular challenges is addressed, enhancing the overall impact of professional development.

**9.4 Strengthen Monitoring, Evaluation, and Feedback Mechanisms**
The use of pre- and post-training confidence surveys proved valuable in assessing workshop impact and guiding improvements. It is recommended that future professional development programmes institutionalize robust monitoring and evaluation frameworks that combine quantitative measures with qualitative feedback. Continuous data collection will enable evidence-based refinement of content, delivery methods, and scheduling, ensuring that training remains responsive to teachers' evolving needs.

**9.5 Facilitate Peer Collaboration and Professional Learning Communities**
The collaborative aspects of the SAIP workshops were positively received and contributed to teacher confidence gains. Building on this, it is advisable to promote ongoing peer networking through professional learning communities (PLCs), either virtually or face-to-face. PLCs can provide platforms for sustained peer support, sharing of best practices, and collaborative problem-solving, which are critical for translating workshop learnings into sustained classroom improvements.

**9.6 Align Training with Curriculum and Assessment Requirements**
To maximize relevance and applicability, professional development initiatives should remain closely aligned with national curriculum standards (CAPS) and assessment frameworks. Tailoring content and instructional strategies to these standards will help teachers effectively navigate curriculum demands and prepare learners for standardized examinations, thus directly impacting teaching efficacy and learner success.

**9.7 Advocate for Policy Support and Resource Allocation**
Finally, the demonstrated effectiveness of targeted teacher training underscores the need for policy-level support and adequate resource allocation. Stakeholders, including the Department of Basic Education, provincial education departments, and professional bodies such as SAIP, should collaborate to secure funding, infrastructure, and institutional backing that facilitate the scaling and sustainability of such initiatives across South Africa.

These recommendations aim to build on the promising outcomes of the SAIP 2025 workshops by fostering a comprehensive, evidence-informed professional

development ecosystem that enhances teacher self-efficacy, pedagogical content knowledge, and ultimately, learner achievement in STEM subjects nationwide.

## 10. Conclusion

This study demonstrates that targeted, content-focused professional development workshops can significantly enhance teacher confidence in teaching critical topics within Physical Sciences and Mathematics. The 69th SAIP Annual Conference Teacher Training Workshop successfully improved teachers' self-efficacy, with average confidence gains of over 16% across all surveyed topics. These improvements were particularly notable in traditionally challenging areas such as redox reactions and electrochemistry, AC/DC motors, calculus, and probability. Teachers expressed strong satisfaction with the workshop format and content, emphasizing the value of interactive, hands-on learning experiences and the need for ongoing support.

Recommendations from participants for quarterly workshops, early-term scheduling, and greater practical engagement highlight important considerations for future professional development programming. The findings underscore the importance of sustained, structured teacher training initiatives as a strategy to strengthen STEM education. By building teacher capacity, such interventions can contribute to improving classroom instruction and ultimately learning outcomes in South Africa. Moving forward, it is vital to expand these efforts, ensuring accessibility across diverse teaching contexts and exploring the long-term impact on pedagogical practice and learner achievement. Through continued investment in teacher development, South Africa can better equip its teachers to meet the demands of the curriculum and foster a more confident, competent STEM teaching workforce.

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