Initial study on leveraging digital tools for geotechnical education: enhancing practical training with databases at CiviLab@CUT

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ABSTRACT: This study explores the development and implementation of the Information System for Geotechnical Engineers (ISGE) at CiviLab@CUT, aimed at improving geotechnical education through digital data management. The ISGE integrates a cloud-based relational database (PostgreSQL, AcuGIS) with automated data validation and error detection, ensuring compliance with SANS 3001 standards. Traditionally, students relied on manual data entry, leading to errors and limited iterative learning. The ISGE addresses these issues by implementing structured validation, automated feedback, and comparative analysis, enabling students to refine testing accuracy. A comparative analysis of historical and newly collected student test data was conducted using statistical methods such as mean absolute error, and standard deviation. Preliminary findings indicate a reduction in data entry errors, improved test result consistency, and enhanced student engagement. The ISGE also supports scalability, with potential expansion into a national geotechnical database to improve data-driven decision-making. By integrating digital tools into practical training, the ISGE enhances geotechnical education, fosters data standardization, and better prepares students for industry challenges through iterative assessment.

Keywords: Geotechnical engineering, Information system, Data management, Integrated student education

1 Introduction

1.1 Background on geotechnical engineering education in the Central University of Technology, Free State

Geotechnical engineering is a fundamental aspect of infrastructure development, ensuring the stability and suitability of soil and rock for construction. In South Africa, laboratory testing in geotechnical engineering is governed by the SANS3001 standards. These standards define procedures for assessing soil properties and material behaviour and are essential for maintaining consistency and reliability in geotechnical investigations and construction practices. The geotechnical characteristics of a site play a crucial role in all phases of construction, from planning and design to implementation and long-term stability. Soil and rock conditions significantly influence construction feasibility, foundation design, and structural integrity. (De, 2015) Neglecting geotechnical assessments can lead to costly failures, as evidenced by numerous international case studies highlighting the impact of inadequate geotechnical considerations on construction projects (Tegtmeier et al., 2009). Ensuring future engineers understand soil assessment through laboratory testing is vital for safer geotechnical design and construction (Coduto et al., 2016). This paper explores how the ISGE system not only minimizes experimental errors but also actively promotes critical thinking and engineering judgment among geotechnical engineering students. By integrating structured feedback mechanisms, comparative analysis tools, and scaffolded learning approaches, the ISGE system serves as a pedagogical tool that enhances students' analytical skills and decision-making capabilities.

CiviLab@CUT, a research group within the Department of Civil Engineering at the Central University of Technology, offers comprehensive training to students through two primary avenues: structured coursework and volunteer-based programs. These initiatives are designed to equip students with both theoretical knowledge and practical skills in geotechnical engineering.

In the structured academic programs, students enrol in courses such as Soil Mechanics I (Diploma level) and Geotechnical Engineering I (Bachelor's degree level). These courses include five practical sessions per semester, where students are assessed on their proficiency in conducting standard geotechnical tests and analyzing the resulting data. Data processing is performed manually or with the assistance of Microsoft Excel, ensuring that students develop a solid understanding of fundamental calculations and data interpretation techniques.

Beyond formal coursework, CiviLab@CUT provides hands-on training opportunities through volunteer programs, work-integrated learning (WIL), and research assistantships. Participants in these programs engage in regular geotechnical testing, gaining exposure to real-world applications and reinforcing data consistency through repeated practice. These experiences encompass the full spectrum of geotechnical workflows, from field assessments of test pits to laboratory analyses of collected samples. Typically spanning one year, these programs are instrumental in developing students' technical competencies and analytical abilities essential for professional practice.

A common challenge observed across these training modalities is the initial variability in test results, often attributed to students' limited experience. While performance tends to improve with practice, the substantial volume of data generated poses difficulties in individualized assessment and feedback. In undergraduate courses, the singular assessment per practical session restricts opportunities for iterative learning and skill refinement. Conversely, WIL participants, despite their frequent testing activities, often lack structured expert evaluations, leading to inconsistencies in quality control and missed learning opportunities.

1. To address these challenges, the Information System for Geotechnical Engineering (ISGE) has been implemented as an integral component of both educational tracks. The ISGE system introduces structured feedback mechanisms that enhance learning outcomes by:
2. Immediate Error Detection: The system flags discrepancies in test results, such as significant deviations in liquid limit measurements, prompting students to reassess their methodologies and calculations.
3. Guided Reflection: Upon identifying errors, students are required to document corrective actions and rationalize their decisions, fostering critical thinking and aligning with professional engineering practices.
4. Comparative Analysis: By providing access to historical data, the ISGE system enables students to discern patterns, differentiate between procedural errors and natural soil variability, and develop informed engineering judgments.
5. Scaffolded Skill Development: The system supports novice learners by offering structured guidance, while gradually encouraging autonomy as students gain proficiency, thus balancing automated assistance with the cultivation of independent analytical skills.

The integration of the ISGE system into CiviLab@CUT's training programs has proven effective in enhancing the quality and consistency of geotechnical education. By facilitating iterative learning, promoting critical analysis, and providing a platform for comprehensive feedback, the ISGE system ensures that students are better prepared to meet the demands of professional geotechnical engineering practice.

1.2 The information system for geotechnical engineers (ISGE)

The Information System for Geotechnical Engineers (ISGE) was developed in the CiviLab@CUT to address challenges in geotechnical data management, accessibility, and decision-making in South Africa. Traditional geotechnical practices often relied on paper records and scattered Microsoft Excel files, leading to inefficiencies, data loss, and restricted access to critical test results. The ISGE provides a centralized system designed to improve the storage, retrieval, and analysis of geotechnical test data. It also ensures compliance with SANS3001 standards and supports more informed engineering decisions.

One of the primary motivations behind the ISGE was to enhance the desktop study phase of site investigations. Desktop studies serve as preliminary assessments before detailed geotechnical investigations and involve reviewing topographical maps, historical geotechnical data, and geological information to identify potential risks. In South Africa, access to past geotechnical data is often limited, making site feasibility assessments difficult. The ISGE was developed as a database-driven system to overcome these limitations by structuring geotechnical test results into an accessible and standardized format.

The ISGE was designed to bridge the gap between academic research and industry application. Developed by CiviLab@CUT, the system provides students, volunteers, and industry professionals with a structured platform for storing, retrieving, and comparing geotechnical test results. By improving data consistency and accessibility, the ISGE enhances long-term knowledge retention and supports better decision-making in geotechnical investigations.

Scalability was a key consideration in the development of the ISGE. The system is designed to evolve into a national geotechnical database, where engineers across South Africa can contribute and access historical soil test data. This broader integration could significantly improve regional geotechnical analysis, infrastructure planning, risk assessment, and research applications.

The ISGE was, therefore, integrated into undergraduate coursework, volunteer training programs, and work-integrated learning (WIL), for this study to evaluate the potential impact of the ISGE on student performance over time, examining its role in improving accuracy, efficiency, and the interpretation of geotechnical data.

2 Literature review

2.1 Importance of geotechnical testing

Geotechnical engineering, a sub-discipline of civil engineering, focuses on understanding the physical properties of soil and rock to ensure the stability of structures. Soil mechanics, as a key component, examines soil behaviour under various forces, making geotechnical investigations crucial for construction planning and design (Das, 2013; Waters, 2022). Site investigations typically involve a combination of desktop studies, field tests, and laboratory analyses. The desktop study includes a review of geological and topographical maps, while fieldwork consists of test pits, boreholes, and soil sampling. Laboratory tests, which form the core of geotechnical evaluations, provide detailed information on soil composition, strength, and behaviour under different conditions (Craig, 2005; SANRAL, 2013). Performance-based tests, including California Bearing Ratio (CBR), direct shear, triaxial shear, and one-dimensional consolidation tests, further aid in categorizing soils and predicting their response to loading.

2.2 Standardized geotechnical testing methods

Geotechnical engineering relies on standardized testing to ensure consistency and reliability in soil characterization. In South Africa, the SANS 3001 series govern civil engineering test methods, having replaced the older TMH1 standards to align with international best practices (South African National Roads Agency, 2013; SABS, 2013). These standards define procedures for essential tests such as Atterberg limits, CBR, and consolidation testing, providing a framework for assessing soil behaviour under various loading conditions (Das, 2013; Craig, 2004). However, despite their technical rigor, practical challenges arise in educational settings. Students often face difficulties with procedural complexities and the variability of soil data (Waters, 2022). Errors in data entry, inconsistent execution, and limited feedback opportunities reduce the pedagogical effectiveness of traditional lab instruction (Viljoen, 2006), highlighting the need for enhanced support systems that maintain standards compliance while facilitating student learning.

2.3 Laboratory learning in geotechnical education

Laboratory testing is central to soil mechanics education, offering students hands-on opportunities to bridge theory and practice (Feisel & Rosa, 2005). Effective laboratory experiences promote technical proficiency and engineering judgment, especially when students are encouraged to interpret their own results and confront uncertainties (Kolb, 1984). Yet, without structured guidance, laboratory sessions may result in surface-level learning where procedural completion takes precedence over conceptual understanding (Domin, 1999). To foster critical thinking and reflective analysis, laboratories must be intentionally designed to develop interpretive skills and empirical reasoning.

2.4 Formative Assessment and Digital Tools in Engineering Education

Modern engineering education increasingly emphasizes formative feedback and iterative learning as essential for developing technical competence and critical thinking. Studies show that formative assessments with opportunities for repeated practice enhance engagement and lead to mastery in engineering contexts (Burns et al., 2023; Ramesh et al., 2023). Technology-enhanced learning environments that offer immediate, multiple-attempt feedback reduce student stress and promote inclusive, equitable learning experiences. Furthermore, integrating digital tools into practical education supports scaffolded and mastery-based learning, encouraging students to take ownership of their development (Diery et al., 2024). Systems like ISGE exemplify this shift by embedding real-time validation, comparative analysis, and reflective activities into student workflows—bridging the gap between theoretical knowledge and applied engineering judgment.

2.5 Educational role of validation and standardization systems

Recent studies in STEM education have explored the role of validation systems that highlight incorrect data inputs or flag inconsistencies (Formanek et al., 2021; Daheim et al., 2024). While there is concern that students may become dependent on such systems, research suggests that when used alongside reflective activities and instructor guidance, automated checks can actually increase awareness of errors and lead to improved understanding over time (Van der Kleij et al., 2015; López-Crespo et al., 2022). In geotechnical engineering, where data scatter and procedural inconsistency are common among novices, structured systems can reinforce standard practices and help students differentiate between material variability and methodological error.

2.6 Information systems and databases

An information system is a software framework designed for storing, organizing, and retrieving data. In geotechnical engineering, such a system must facilitate structured data management, integrating various test results to assist engineers in decision-making. The Information System for Geotechnical Engineers (ISGE) follows this principle, ensuring accessibility, comparability of historical and current data, and standardization of test results (Ramesh, 1997). A user-friendly interface for transforming raw test readings into meaningful information is essential, aligning with SAICE Code of Practice for geotechnical investigations. The ISGE is designed to be scalable and adaptable, allowing expansion to incorporate future geotechnical tests and database enhancements (Viljoen, 2006).

A database is a structured collection of data stored and accessed electronically, managed by a Database Management System (DBMS). Proper database design is crucial to ensure data integrity, accessibility, and efficient decision-making. Raw data, when processed, becomes meaningful information, forming the foundation for informed engineering decisions. A Relational Database Management System (RDBMS) organizes data into tables (relations), where rows (records) store individual entries and columns (fields) represent attributes. A primary key uniquely identifies each record, ensuring referential integrity between tables (Satzinger et al., 2012).

A key feature in relational databases is normalization, a formal process used to reduce redundancy and enhance flexibility. By structuring data correctly, normalization ensures that databases remain scalable and adaptable to future changes. The ISGE employs these principles to provide a dynamic, real-time geotechnical data management system, supporting standardized reporting, historical data comparisons, and streamlined decision-making in South African geotechnical engineering.

3 Methodology

This study employs a structured approach to enhancing and evaluating the effectiveness of the Information System for Geotechnical Engineers (ISGE) in geotechnical education. The methodology consists of two primary phases: system improvements and student engagement, which will be followed by comparative analysis of student results over time. The first phase focused on refining the ISGE by implementing automated data validation checks, error detection mechanisms, and comparative data analysis. These improvements ensured that student-entered data adhered to predefined thresholds and SANS3001 standards. The system was also designed to store, retrieve, and compare test results through queries made via the Open Database Connectivity (ODBC).

Following these modifications, students are granted limited user access to the ISGE database to input test results. This phase allowed students to engage with the database, ensuring they followed structured data entry procedures while integrating their test results into the system.

The ISGE system is designed to complement traditional soil mechanics education by integrating structured feedback loops that promote deeper understanding. Key features include:

1. Collecting historical test results from past student groups in Geotechnical Engineering I and Soil Mechanics I for Atterberg limits (Practical 2 in course). Each class had between 60 and 120 students per semester. Previous results of WIL students and volunteers (estimate of 50 students) will be imported into the database.
2. Recording new student test results obtained through the ISGE.
    - Students conduct the Casagrande cup test to determine liquid and plastic limits.
    - Students input their results into Excel sheets, which perform preliminary validation. The system flags significant discrepancies, such as liquid limit variations exceeding 7% or incorrect relationships (e.g., a plastic limit higher than the liquid limit).
    - Results are stored in the ISGE database, with student-entered data tagged separately to prevent its use in industry applications.
    - Server-based SQL scripts and Excel calculations analyze all submitted results, generating standard deviations, ANOVA tests, and distribution curves. The system also cross-references results against other tests from the same sample to verify consistency.
3. Structured course students receive direct feedback from lecturers or mentors, while experienced volunteers can review system-generated assessments to identify and correct errors in their results. Comparing accuracy trends by analyzing variations in test results, identifying improvements, and assessing whether error rates decreased over time.

Figure 1 demonstrates the discussed approach for using the ISGE system for enhancing geotechnical education through a structured, data-driven approach. The collection of results will be an iterated cycle of assessing the student results and provision of feedback through lecturers or self-assessment.

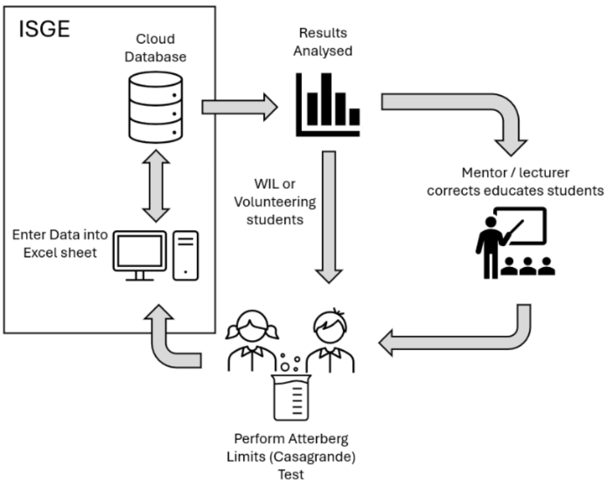


Figure 1. Process of assessing results

The ISGE system was not designed merely to reduce error rates, but to serve as a scaffold that promotes deeper learning and the development of engineering judgement. In traditional laboratory settings, students often receive minimal feedback on their results and have limited opportunity to revise or question flawed outcomes. As a result, learning is often procedural, with students prioritizing test completion over understanding variability or identifying test anomalies.

By integrating real-time validation checks and structured feedback based on SANS 3001 standards, the ISGE shifts the focus from compliance to reflection. When students receive automated warnings about implausible results (e.g., plasticity index inconsistencies), they are prompted to critically examine their procedures, materials, and assumptions. Rather than simply accepting system-generated warnings, students are encouraged to interpret them, reflect on potential sources of error, and revise their approach. In this way, the system acts as a diagnostic guide, not a prescriptive authority.

Furthermore, students are not penalized for submitting flawed results; instead, instructors emphasize that flagged results are learning opportunities. During laboratory follow-up sessions, students are asked to justify their choices, discuss flagged anomalies, and identify whether discrepancies stemmed from procedural mistakes, equipment limits, or natural soil variability. This process cultivates data literacy, reinforces standard compliance, and helps students distinguish between random variation and methodological error—key components of geotechnical competence.

For WIL and volunteer students, the ISGE serves as a tool for independent self-regulation. Over time, trainees develop an internalized sense of data quality and procedural rigour, with the system providing structure but not dependency. Monthly feedback sessions reinforce this autonomy, with students presenting and interpreting their own performance trends using the system's analytics.

3.1 Fostering Critical Thinking Through Iterative Feedback

Early implementation has shown measurable impact. For example, students now receive immediate feedback when entering data that violates standard thresholds. This has led to a marked reduction in erroneous submissions. Students are also more reluctant to submit incomplete or invalid results — a shift attributed to the system's feedback mechanisms, which highlight errors and explain their likely causes. This change has led to a lower volume of submitted data, but with significantly improved reliability.

Additionally, the ISGE's ability to consolidate results into a standardized format has supported both teaching and mentoring. Structured feedback, either through the system or from instructors, is now directly tied to student entries, reinforcing correct procedures and helping students correct misunderstandings. The system's alignment with real-world data practices has also encouraged greater student ownership of the results they produce. The structure of the ISGE is shown in Figure 2.

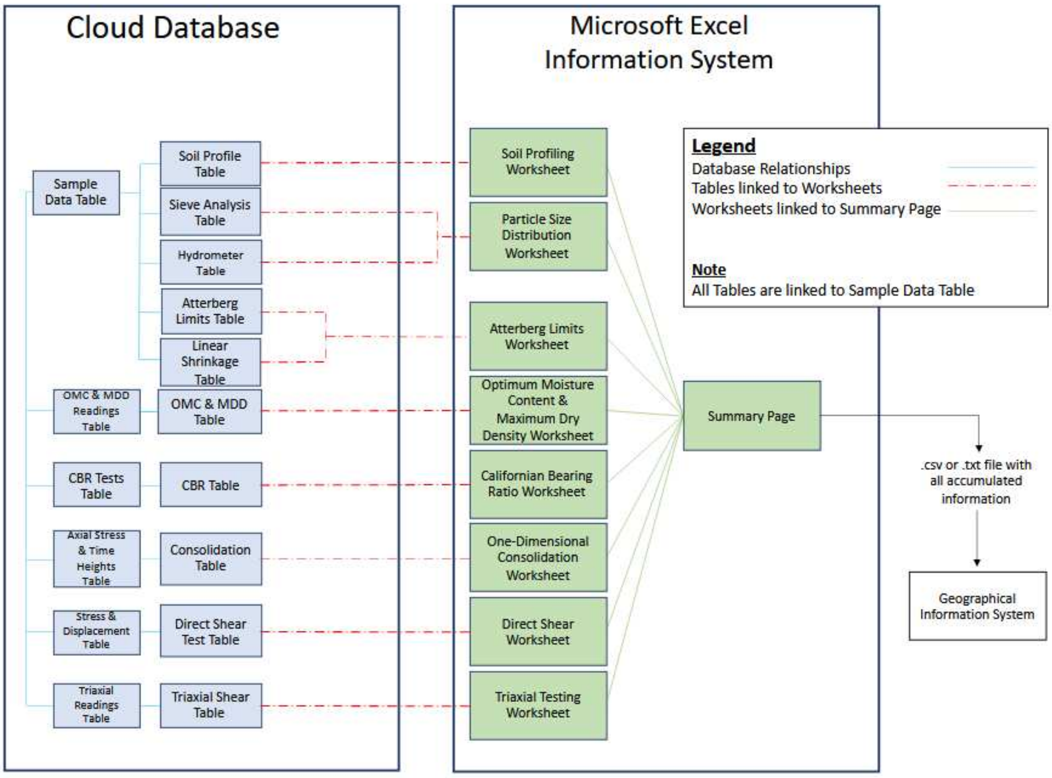


Figure 2. Layout of ISGE system

3.2 Database design and implementation

The database for the (ISGE) was developed to provide a structured approach to storing and managing geotechnical data. The design follows a relational database model, ensuring efficient data organization, integrity, and accessibility. Microsoft Access was initially chosen as the primary database platform due to its ease of use and seamless integration with Microsoft Excel, which was used for advanced calculations, visualization, and automated reporting. However, the database has now been uploaded to a cloud-based storage (AcuGIS, PostgreSQL) to allow better sharing capabilities and collaborative access among users. The transition to AcuGIS with PostgreSQL enhances the system's scalability, allowing multiple users to input, retrieve, and analyze geotechnical data simultaneously from across the country (keeping scalability in mind). This cloud-based solution improves data security, backup reliability, and accessibility, ensuring that test results and site investigation records are preserved without risk of local storage failures.

The database structure consists of multiple tables, each representing a specific geotechnical test such as particle size distribution, Atterberg limits, California Bearing Ratio (CBR), and one-dimensional consolidation tests. A primary table stores essential sample data, linking all other tables through one-to-many relationships, ensuring each test result is associated with a unique sample identification ("sample_id). This relational structure prevents data redundancy, enhances data integrity, and enables efficient queries.

To facilitate data retrieval and analysis, queries were created to aggregate data from multiple tables. These queries provide engineers and students with structured test results, enabling effective comparison of historical and current data. The summary page interface within the ISGE compiles geotechnical test results, providing a clear overview of key parameters.

One of the critical components of the database design was ensuring compliance with SANS3001 standards, which regulate geotechnical testing in South Africa. The database structure allows for the storage and manipulation of geotechnical test data according to these standards, ensuring consistency and regulatory adherence.

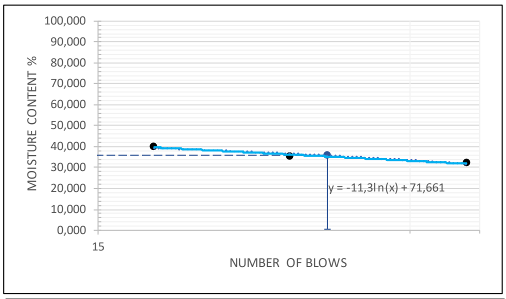
4 Modifications to the ISGE for assessing geotechnical test results

A crucial modification was the implementation of automated feedback and quality control measures to assess student and engineer-entered test results. These mechanisms detect potential errors, flag anomalies, and verify compliance with SANS3001. The error-checking functionality automatically compares input values against predefined threshold ranges. For example, Atterberg limit test results are assessed based on standard plasticity index ranges, while CBR test results are checked against expected strength values. If discrepancies arise, the system highlights outliers and prompts users to review the data, minimizing inaccuracies in geotechnical reporting.

Beyond direct error detection, the ISGE includes statistical analysis tools that compare historical test results with new data, allowing users to determine whether variations are due to soil heterogeneity or potential testing errors. This feature is particularly valuable for long-term site monitoring and research applications, where consistency in geotechnical properties must be tracked over time. The summary page interface plays a central role in quality control by consolidating all test results into a standardized report format, ensuring clarity in geotechnical assessments. Additionally, the system can generate SANS3001-compliant test reports, ensuring that all documentation meets regulatory standards. The ISGE improves geotechnical test assessment by integrating automated validation (as shown in Figure 3), statistical analysis, and cloud-based accessibility. These modifications enhance the accuracy of student test results, minimising human error through correcting the results obtained, and improving the overall reliability of geotechnical investigations in South Africa.

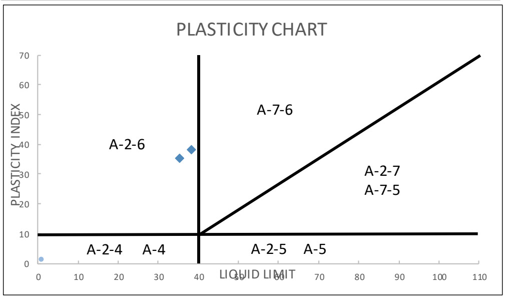
ATTERBERG LIMITS (SANS3001 GR10, GR11, GR12)

Soil description	
Location / Site:	Langenhoven Park
Job ref:	LHP (Stuck in the mud)
Borehole/ Testpit ref:	TP1
Sample ID:	LHP_TP1_L1
Depth (m)	3,1
Date	30/09/2024
Engineer	Kikine

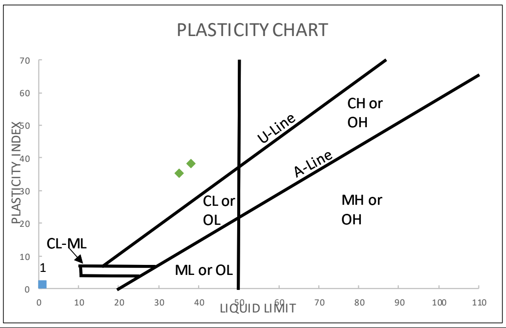


Liquid Limit			
Method	Flow Curve		
	A (15 - 22 Taps)	B (22- 28 Taps)	C (28 - 35 Taps)
Tin Number	68	69	70
Number of Taps	17	23	34
Mass Tin + Wet (g)	17,87	17,68	18,67
Mass Tin + Dry (g)	17,53	17,42	18,24
Mass Tin (g)	16,68	16,69	16,9
Mass Moisture (g)	0,34	0,26	0,43
Mass Dry (g)	0,85	0,73	1,34
% Moisture	40,000	35,616	32,090
Final Liquid Limit	35,753		

Plastic Limit			
Tin Number	61	63	
Mass Tin + Wet (g)	16,17	18,71	
Mass Tin + Dry (g)	15,99	18,43	
Mass Tin (g)	14,76	16,72	
Mass Moisture (g)	0,18	0,28	
Mass Dry (g)	1,23	1,71	
% Moisture	14,63414634	16,37426901	



	A
L_L (%)	35,753
P_L (%)	15,50420767
P_I (%)	20,2486302
Linear Shrinkage	
f	0,616898148
q	6
L_S	3,701388889



Comments	
Previous results	5 Tests were previously performed on this sample (Atterberg Limits) - 3 verified to be correct
PI	PI is 5,73% higher than the average result
Error	Liquid limit: exceeding 7% between duplicate test results - Not Acceptable (SANS3001 - GR12)
Entry checks	All entries meet standard requirements.
Recommendation	**Check SANS3001 GR 12 - 7,2; Redo test**

Figure 3. Example of data verification and comparison in Atterberg Limit data entry sheet

This sheet automates the initial assessment of results in compliance with SANS 3001 regulations, preventing invalid data from being entered into the database. Figure 3 illustrates a case where the difference between data points exceeds 7%, triggering an assessment of input validity. The system also references the relevant standards, providing students with targeted feedback to identify and correct errors.

4.1 Comparative analysis of learner test results

Preliminary observations indicate that the ISGE has already led to noticeable improvements in student data quality and engagement. The system's built-in validation checks prevent the submission of incomplete or implausible results, leading to a sharp reduction in the number of invalid test entries. For example, students are no longer able to proceed with uploading Atterberg limit data that violates fundamental consistency rules, such as a plastic limit higher than the liquid limit or a liquid limit variation exceeding 7%. These technical constraints have translated into a significant behavioural shift: students are now more cautious and deliberate when conducting tests and entering data, often opting to repeat a test rather than submit flagged results.

This behaviour reflects a growing awareness of quality standards and a greater alignment with professional geotechnical practices. It also suggests that students are engaging in more iterative learning — revisiting procedures, questioning anomalous results, and seeking clarification from mentors. This aligns with one of the core goals of the ISGE: to promote reflective, standards-based practice that mirrors real-world engineering environments.

While full statistical analysis is still ongoing, early trends are promising. The initial datasets show narrower standard deviations in student test results compared to historical data, suggesting improved consistency. A decline in data variability is particularly evident among Work-Integrated Learning (WIL) students, who are now using ISGE for extended periods across multiple testing sessions. As the dataset grows throughout 2025, the system will support more robust statistical analysis using descriptive metrics such as mean absolute error (MAE), standard deviation, and linear regression trends to track improvement trajectories.

Importantly, the ISGE tags student-entered results distinctly from professional datasets, allowing for safe inclusion in the learning environment without compromising industry reporting. This dual-purpose design enhances student accountability while ensuring educational use remains clearly separated from operational applications.

While the initial implementation of ISGE led to a decrease in the number of test results submitted, this was not due to grade anxiety or fear of penalties. Students were explicitly informed that flagged data would not negatively affect their marks and that the system was designed as a formative learning tool. The observed decrease instead reflects a shift in student behaviour: many chose to repeat tests when inconsistencies were highlighted, seeking to produce more accurate results. Informal feedback and classroom discussions revealed that students became more aware of procedural accuracy and expressed increased confidence in interpreting standards-based results. In future iterations, students will be encouraged to submit flawed results alongside written reflections, enabling deeper insight into their understanding and decision-making process. This reflective submission strategy will ensure that hesitation to submit does not inhibit learning but becomes an opportunity for metacognitive development.

5 Conclusions and future work

The implementation of the Information System for Geotechnical Engineers (ISGE) at CiviLab@CUT marks a meaningful advancement in geotechnical education. By combining a cloud-based relational database (PostgreSQL, AcuGIS) with structured validation and feedback mechanisms, the ISGE directly addresses key challenges of data accuracy, management, and standardization in student laboratory work.

Early results indicate a clear reduction in submission errors, greater consistency in student test data, and a shift in behaviour toward more reflective, standards-driven testing practices. These outcomes suggest that the system not only improves the reliability of practical assessments but also supports iterative learning through immediate, targeted feedback. Importantly, the integration of SANS 3001 compliance into the learning process reinforces industry-aligned procedures from the outset.

As data collection continues throughout 2025, further analysis will be used to quantify long-term improvements in student performance and evaluate broader educational outcomes. Future work will focus on expanding ISGE's statistical and reporting capabilities, investigating industry integration, and exploring the feasibility of a national geotechnical database to enhance collaboration and data reuse across South Africa.

By embedding regulatory standards into student workflows and offering structured feedback, the ISGE establishes a scalable model for bridging the gap between academic training and professional geotechnical practice. It provides a foundation not only for better student outcomes, but also for a more data-driven, standardized approach to geotechnical testing nationwide.

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Authors' bios

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Samuel Waters is a lecturer in Geomatics and Engineering Surveying at the Central University of Technology, Bloemfontein, with seven years of academic experience. He also teaches the final-year Project subject, integrating practical applications with theoretical knowledge. His research focuses on database design, problematic soil identification, road inspection, and Geographic Information Systems (GIS). He has contributed to the field through publications and conference presentations, with his work recognized by the National Research Foundation of South Africa, which awarded him a Thuthuka Research Grant for 2025. Samuel is committed to advancing geospatial and geotechnical methodologies, particularly in South Africa's diverse soil and infrastructure environments.

Elizabeth Theron, Central University of technology, Free State (South Africa)

Professor Theron has over 35 years of experience in academia, with a strong focus on geotechnical engineering. She has developed innovative teaching materials and methodologies, significantly enhancing student learning experiences. Her research, particularly on foundation problems related to heaving clays, has earned her multiple awards, including the J.E. Jennings Award from the South African Institution of Civil Engineering for three consecutive years (2017-2019). In addition to her academic roles, she actively participates in community projects, such as the Pothole Eradication Programme, demonstrating her commitment to applying engineering solutions to real-world challenges. As a registered Professional Engineering Technologist with the Engineering Council of South Africa, she maintains high professional standards in her work.