A Retrospective on South Africa's Student Cluster Competition and its Model for Inclusive HPC Outreach and Training (2012-2020)

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ABSTRACT

The Centre for High Performance Computing (CHPC) is South Africa's national supercomputing facility. In 2012, it launched an outreach initiative to raise awareness of High-Performance Computing (HPC) among undergraduate students through the creation of the Student Cluster Competition (SCC). A national contest was designed to train and showcase student talent in a spirited, hands-on environment. The initial stage of the CHPC SCC saw twenty teams of four undergraduate students undergo an intensive week of HPC training, covering Linux fundamentals, cluster design, and system administration. Finalists from this selection round would then compete in a live challenge using HPC systems of their own design, with the top competitors selected to represent the CHPC at the International Student Cluster Competition hosted at the ISC High Performance conference in Germany.

From its inception, the CHPC SCC has prioritised demographic diversity and equal opportunity, actively recruiting students from historically disadvantaged communities to ensure inclusive participation and representation. A rapid teaching framework was developed to address key knowledge gaps in HPC system design, administration, and optimisation: the empowerment of students with limited prior exposure in the field of HPC to excel. This approach has proven highly effective: South African teams ranked in the top three internationally for eight consecutive years, demonstrating the strength of the program.

This paper presents the strategy and structure behind the CHPC SCC, detailing the training model, selection process, and evaluation methods used for both national and international rounds. It highlights how the initiative has evolved into a recognised platform for HPC education, enabling students to learn about HPC and become global contenders in the field.

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KEYWORDS

HPC Education, Student Cluster Competition, Diversity in HPC, Best Practices in Training, International Cooperation, Workforce Development, South Africa

1 INTRODUCTION

The Centre for High Performance Computing (CHPC)[1] is South Africa's national supercomputing facility. It was established to support computational research in scientific and industrial fields. In 2012, the CHPC identified a critical and persistent skills gap: undergraduate students received little to no theoretical or practical exposure to High-Performance Computing (HPC). The gap was evident across the South African tertiary education landscape, but it was most pronounced among students from historically disadvantaged institutions (HDI's) and under-served communities. These groups in particular faced compounded barriers - limited access to computing infrastructure, scarce opportunities for specialist training, and systemic exclusion from emerging computational fields.

To bridge this gap, the CHPC launched the Student Cluster Competition (SCC), a national initiative designed to raise awareness, cultivate core technical competencies, and establish a pipeline of future HPC practitioners within the country. The SCC model introduced a novel blend of hands-on education and competitive participation, positioning HPC as a powerful research instrument and a dynamic, team-based discipline accessible to talented undergraduate students.

By combining merit-based selection with inclusive outreach, the SCC reimagined HPC as a field in which students from diverse backgrounds in South Africa could not only gain exposure to advanced computing technologies, but also earn the opportunity to represent their country on the global stage at an international Student Cluster Competition.

2 HISTORY

In 2011, at the Association for Computing Machinery (ACM) and Institute of Electrical and Electronics Engineers (IEEE) Computer Society's SC conference (formerly Supercomputing)[2], the HPC Advisory Council[3] introduced the CHPC to its newly established Student Cluster Competition (SCC) programme, which was due to

[1]CHPC homepage: https://www.chpc.ac.za
[2]SC'11: https://sc11.supercomputing.org/
[3]HPC Advisory Council: https://www.hpcadvisorycouncil.com/

Table 1: Phased Development of the CHPC Student Cluster Competition Programme (2012–2021)

Phase	Years	Characteristics	Representative Milestones
Establishing	2012–2014	Programme launched without a prior model. Structure built from first principles with improvised materials and initial outreach.	2012: first Winter School and national competition. 2013: ISC SCC Overall Champions at first attempt. 2014: ISC SCC Overall Champions.
Consolidation	2015–2018	General framework stabilised. Growing institutional participation and consistent performance.	2015: ISC SCC 2nd place. 2016: ISC SCC Overall Champions. 2017: ISC SCC 2nd place. 2018: ISC SCC 3rd place. CHPC SCC introduces Intel-sponsored award for best female student.
Maturity and Handover	2019–2021	Operational maturity established. Leadership transition began, sponsor support deepened and innovation slowed.	2019: ISC SCC Overall Champions. Major sponsorships secured. 2020: ISC SCC 2nd place. 2020–21: virtual and hybrid adaptations during handover.

commence in 2012 at the ISC High Performance conference[4], formerly the International Supercomputing Conference. As a new initiative, the HPC Advisory Council actively promoted the competition and recruited teams from across the world. Given that Africa had not previously been represented in the SCC, the Council extended an invitation to the CHPC to participate in the inaugural event.

Owing to strategic considerations, the CHPC declined the invitation. Two critical constraints were immediately evident: the near total absence of HPC education and training at South African universities, and the limited time available to prepare a team capable of meaningful participation. Instead, the CHPC proposed spending the next year and a half building a national SCC programme, with a focus on identifying and training students to prepare a team for participation in the 2013 ISC Student Cluster Competition (ISC SCC). This proposal was endorsed by the HPC Advisory Council.

This approach gave the CHPC sufficient time to decide what it wished to achieve from participation in the ISC SCC, rather than making participation itself the sole goal. Table 2 summarises the identified key objectives:

Table 2: CHPC SCC Identified Objectives

• Expose as many students as possible to HPC • Increase participation by students from previously disadvantaged communities • Increase participation by women • Prepare teams to be competitive at the ISC SCC

As a national supercomputing facility, the CHPC primarily serves the South African higher education sector and does not maintain its own student body. It therefore needed to collaborate directly with universities, and this engagement required a transparent approach to ensure equitable access for all institutions.

Within two years the structure produced international success. In all, CHPC teams captured the ISC SCC Overall Championship in 2013, 2014 and 2016. They also achieved podium finishes in 2015, 2017, 2018, 2019, and 2020. This level of achievement, attained with rotating undergraduate teams where few students competed more than once, demonstrated both elite performance and wide distribution of experience across the student community [8].

3 PROGRAMME PHASES

The evolution of the CHPC's SCC over its first decade can be described in three developmental phases, each marked by specific organisational priorities and outcomes. This phased view highlights how the programme matured from inception to operational stability while maintaining a consistent educational mission. Table 1 provides a consolidated overview.

The **first phase** was characterised by experimentation and credibility-building, with a rapid transition from design to international recognition. The **second phase** marked consolidation, with the CHPC becoming a reliable pipeline of competitive teams and embedding inclusivity through its rotation policy. The CHPC mandated undergraduate-only entry from the outset, thereby maximising the number of students able to attend ISC and allowing the national delegation to include students from more than one university; further operational implications are discussed in the National Round section. The **third phase** represented operational maturity, in which the programme had stabilised and secured strong sponsorship, but began to show signs of needing strategic renewal. The leadership handover during this time created the conditions for the next era, which falls outside the scope of this account.

4 PROGRAMME DETAILS

The CHPC established a structured competition programme culminating in international representation at ISC SCC, as summarised in Table 3. Teams progressed through multiple stages, with participation limited to South African universities after initial attempts to

[4] ISC SCC: https://isc-hpc.com/program/student-cluster-competition/

Table 3: Structured Annual Progression of the CHPC Student Cluster Competition

Round	Timeline	Focus	Purpose / Outcome
Selection Round	January to July	Inclusive, low-cost IT, Linux, and HPC exposure; theory and practical training	Raise awareness of HPC; build foundational skills; identify promising student teams.
National Round (CHPC SCC)	July to December	Small scale ISC SCC-like competition; hands-on cluster assembly; benchmarking and testing	Simulate ISC SCC experience; select national team; prepare for international representation.
International Round (ISC SCC)	December to June (next year)	ISC SCC preparation and participation; intensive technical refinement; team coordination and tuning	Represent South Africa at ISC SCC; compete internationally; showcase national HPC talent.

include broader Southern African institutions proved logistically unfeasible. The framework underpinning the programme's delivery encompasses the organising committee, its pedagogical approach, and commitments to diversity and inclusion. Later subsections (Selection Round, National Round, International Round) provide detailed accounts of each competitive stage.

4.1 Organising Committee and Operations

The programme's sustained success stemmed from a collaborative leadership structure centred on the Advanced Computer Engineering (ACE) Lab, which serves as the CHPC's research and development unit. The organising committee combined strategic oversight with operational expertise, integrating technical, pedagogical, and logistical responsibilities under unified leadership. Collective experience and institutional memory proved instrumental in maintaining programme identity and operational stability.

Leadership: The ACE Lab head provided strategic continuity across multiple cycles, supported by engineers and technologists whose expertise spanned systems and cluster architecture, benchmarking, Linux systems, and pedagogy. This core ensured consistent standards while adapting to evolving competition requirements.

Lectures: Instruction was delivered by domain specialists and co-presenters, balancing technical depth with skill development. Guest lecturers from HPC-adjacent fields contributed expertise in areas such as benchmarking methodologies and scientific applications. The programme also created opportunities to upskill staff beyond the ACE Lab, extending institutional capacity.

Logistics: The programme's logistics were demanding, as multiple competition cycles had to be organised in parallel. The Selection Round was co-hosted with the CHPC Winter School[5] and relied on partnerships with host universities to provide lecture venues, computer laboratories, catering, and frequently accommodation. This model significantly reduced both costs and coordination burdens through shared infrastructure. The National Round, held alongside the CHPC's annual conference[6], required teams to assemble physical clusters supplied on loan by hardware sponsors. Equipment was usually delivered only a few days before the competition and returned immediately afterwards, which preserved the authenticity of the exercise while limiting storage and shipping costs. The International Round, hosted by ISC High Performance in Germany, introduced still greater complexity. Hardware specification finalised early in the year was shipped to Cape Town for assembly, exported to Germany for staging in ISC warehouses, and eventually returned to the manufacturer. Despite this intricate sequence, deliveries were consistently completed on time.

Materials development: Curriculum development was closely aligned with the ACE Lab's research mandate. Early initiatives such as the Ranger Project and the HPC Ecosystems Project[7] [3, 5] informed course content and provided training platforms, in addition to their original purpose of equipping the African continent with HPC capability. Internal research on hybrid cloud–HPC management systems and software-defined infrastructure [2, 7] also shaped tutorials and practical exercises for participants. However, automation tools were deliberately excluded to ensure equitable access across institutions with differing resources. Students instead carried out manual deployments, an approach that reinforced fundamental skills while maintaining relevance in diverse institutional environments.

4.2 Pedagogy Framework

The SCC's competitive structure was designed to motivate engagement while supporting educational inclusivity. The challenge lay in ensuring that advanced teams did not outpace novices in ways that limited broader learning. The pedagogical framework addressed this tension through a staged progression: **foundational skills** in the Selection Round, **applied practice** in the National Round, and **synthesis with evaluation** in the International Round. Each stage reinforced the previous, deepening knowledge while preserving accessibility for participants from diverse academic and institutional backgrounds. Detailed curriculum design and delivery are described in the later round-specific subsections.

[5] CHPC Winter School: https://wiki.chpc.ac.za/workshops:practicalhpc
[6] CHPC Annual Conference: https://chpcconf.co.za/
[7] Internationally funded capacity-building initiatives that deployed HPC clusters and training programmes across Southern African universities.

4.3 Diversity and Inclusive Opportunities

Diversity formed an explicit element of the programme's design. Outreach activities included targeted engagement with historically disadvantaged institutions, and selection criteria considered both demonstrated technical performance and indicators of future development potential. Team composition aimed to reflect South Africa's demographic profile while maintaining merit-based progression. In practice this approach resulted in the inclusion of students with limited prior exposure alongside more experienced peers, extending participation across a broader cohort.

At the international stage, team size increased from four to six members in line with competition rules. The CHPC addressed this by supplementing the winning national team with outstanding individuals drawn from runner-up teams, resulting in hybrid delegations that represented multiple institutions. From the CHPC's perspective this structure was a distinctive feature of the programme, enabling broader representation while maintaining competitiveness. Recognition of underrepresented groups was also formalised; for example, in 2018 Intel sponsored an award for the best female student, highlighting the programme's emphasis on equitable participation [9].

4.4 First Round — "Selection Round"

The first round of the CHPC SCC serves as the programme's main entry point and the largest contributor to national impact. It provides students with a shared foundation, supports the identification of promising teams, and begins the pipeline that ultimately leads to international representation at ISC SCC. Participation is restricted to South African universities, and admission is determined through a combination of institution-ranked nominations and CHPC allocation to ensure equitable representation.

Curriculum overview: The week integrates lectures with hands-on laboratory work. Students begin with Linux fundamentals and basic system administration before progressing to clustering concepts that emphasise hardware trade-offs and essential software layers. They then move on to creating virtual clusters and configuring basic networking through a graphical cloud interface, followed by the installation of a standard HPC software stack, including compilers, MPI, and scientific libraries. The programme concludes with performance benchmarking using workloads common to SCC competitions, such as HPL and HPCG. Alongside the technical content, newly formed teams establish working norms and practice collaboration.

Delivery model: A host university provides a lecture venue for morning teaching and a computer laboratory for afternoon practicals. This rhythm supports immediate application of concepts and encourages team-based problem solving. Co-hosting with the CHPC Winter School streamlines logistics and reduces cost through shared facilities and partial sponsorship.

Progression and structure: Learning is scaffolded to align a diverse cohort around a shared baseline, moving from terminology and tooling to system services, parallel programming concepts, and performance measurement. The day-by-day progression and assessment checkpoints are summarised in Table 4. The emphasis is on system-level reasoning rather than mechanical execution, so students document decisions, justify trade-offs, and reflect on failure modes.

Assessment: Teams complete short, graded theory questions that are directly linked to their practical exercises, and progress is monitored against defined milestones to ensure completeness and reproducibility. On Day 1 each team receives a design brief requiring a costed cluster proposal aligned to the theoretical workloads they are assigned. The process culminates on Day 6, when teams present and defend their designs in a timed session before a judging panel that may include past competitors, invited experts, and competition organisers. Evaluation considers benchmark accuracy, the quality of reasoning, and the effectiveness of teamwork. Performance in these areas determines which teams advance to the National Round.

Applications and cohort: Applicants are typically in their second or third year of undergraduate study with strong academic records. First-year students are not considered, as limited prior exposure to computing and a lack of academic grounding make it difficult for them to contribute meaningfully within the intensive timeframe of the competition. Final-year students are also excluded to ensure that selected students remain eligible to represent South Africa the following year at the international round. This policy maximises continuity and strengthens the pipeline by allowing returning participants to advance through successive rounds. Cohorts are intentionally mixed, ranging from experienced programmers to students with minimal prior computing exposure, and the structure, pacing, and mentoring are designed to narrow initial disparities while preserving healthy competition.

4.5 Second Round — "National Round"

The National Round builds directly on the foundations of the Selection Round but places students in a more tightly constrained environment. Held during the CHPC Annual Conference, it requires teams to design, assemble, configure, and validate physical clusters within a compressed timeframe that mirrors the intensity of the ISC SCC format.

Preparation and design: Teams receive a standardised parts list prepared by the CHPC SCC hardware partners, together with a design envelope aligned to the expected applications. Facilitators intervene only in cases of safety concerns or blocking technical issues. Within these boundaries, students make performance-driven choices, manage budget and power constraints, and document the rationale for their decisions.

On-site deployment: Hardware arrives shortly before the event and is returned immediately afterwards. Teams are responsible for the complete deployment process: assembling the systems, installing operating environments, and configuring all required services. In effect, students must act as HPC Linux administrators, diagnosing hardware and software issues under strict time constraints while maintaining a functioning cluster. Beyond bringing the system online, they are also required to compile, install, and tune both synthetic benchmarks and representative scientific workloads. This work extends the skills introduced in the Selection Round and places students in a setting that mirrors the expectations of professional HPC practitioners, where system reliability, performance optimisation, and application readiness must be achieved simultaneously.

Table 4: Learning Progression Across the Selection Round

Day	Main theme	Outcomes / objectives	Assessment method
1	Foundations of HPC and Linux	Recognise core HPC concepts; navigate Linux; basic IPv4 networking	Tutorial lab milestones
2	Hardware and cluster design; debugging	Configure services; understand hardware trade-offs; trace misconfigurations	Lab validation; short written explanations
3	Cluster services; parallel computing	Compile and deploy applications; manage shared services	Tutorial milestones; theory questions
4	Benchmarking and preparation	Execute HPL; finalise theoretical design	HPL execution; design brief
5	Revision and Q&A	Consolidate concepts; reinforce system reasoning	Open Q&A; lab completion
6	Design presentation	Present and defend cluster design; respond to critique	10-minute team talk; 5-minute Q&A

Engagement and communication: In addition to their technical responsibilities, teams interact continuously with judges, conference attendees, and on occasion the media throughout the competition. These interactions take place during the same period as system assembly, configuration, and benchmarking, requiring students to balance communication demands with their technical workload. The format therefore evaluates not only the clarity of explanation, design coherence, and professional conduct, but also the ability to manage time and perform under simultaneous technical and presentational pressures.

Assessment and selection: Required outputs include validated results for synthetic and application-oriented benchmarks, configuration artefacts, and a concise design justification. An external panel evaluates not only the accuracy of results and the quality of reasoning, but also the teamwork and communication demonstrated under competition conditions. Performance across these dimensions determines which students advance to the International Round.

4.6 Final Round — "International Round"

The International Round serves as the capstone and applies the programme's scaffold at full scale. The CHPC formed a six-student undergraduate delegation by supplementing the four-member National Round winning team with two additional undergraduates from other teams so that the delegation represented multiple institutions; in addition, two undergraduate reserves were selected as stand-by members.

Rationale and team composition: From the programme's inception the CHPC required that local teams be undergraduate-only, with four-member teams competing at the National Round. For international participation this winning four was supplemented by two additional undergraduates drawn from other teams, selected as high performers or promising individuals, to form the six-student core delegation permitted by ISC rules. A further two undergraduates were designated as reserves, creating an eight-member national squad in total. Reserves underwent the same pre-departure preparation and skills development, including sessions with engineers at Dell Technologies and staff at the Texas Advanced Computing Center, but only travelled to ISC if a core member was unable to participate. This arrangement maximised opportunity, maintained representation from more than one university, and ensured continuity in the event of unforeseen constraints.

Industry collaboration: Preparation includes design review and skills development with engineers at Dell and staff at the Texas Advanced Computing Center. Sessions cover current HPC technologies, configuration practice, power monitoring and budgeting, and benchmarking methodology. Students present a proposed system design, receive feedback, and iterate before finalisation.

Training and roles: With the design set, students assemble and tune the system, validate workloads, and explore performance limits. Roles emerge naturally, for example application specialist and systems administrator, reflecting how tasks will be divided in competition.

Logistics: The international shipping sequence has several stages. Hardware is finalised early in the calendar year, shipped to Cape Town for assembly and testing, exported to Germany for staging at ISC, and returned to Europe by way of South Africa after the event. The chain demands careful scheduling and coordination but was consistently delivered on time.

Competition: At ISC High Performance the team reassembles the system, verifies stability, and completes assigned workloads within strict time and power limits. Facilitators step back to an advisory role while students execute independently. The round is both a contest and a training loop: alumni return as mentors, feeding experience back into the Selection Round and National Round.

5 ASSESSMENT AND EVALUATION

The effectiveness of the CHPC SCC programme is evaluated using performance standards, participant feedback, and longitudinal review across the following dimensions:

- **Programme throughput and access**: The rotation rule prevents repeat participation at ISC and the international roster is limited to six students per year. The undergraduate-only mandate and four-to-six supplementation were adopted to

adopted to maximise international exposure and broaden institutional representation.
- **Competition performance**: Consistent international results were achieved over 2013–2020, including overall wins in 2013, 2014, 2016 and 2019; second place in 2015, 2017 and 2020; and third in 2018.
- **Participant outcomes**: Alumni have progressed into high-performance computing, data science and engineering, with many taking roles in national research institutes and industry.
- **Diversity impact**: Recent cohorts included more than half historically disadvantaged participants, with representation from all nine provinces, in line with the outreach and selection approach.

Evaluation methods include pre- and post-course questionnaires to track skill development, analysis of competition results against established benchmarks, and longitudinal follow-up of alumni to assess academic and professional trajectories.

6 RELEVANCE AND APPLICATION

The CHPC SCC model has demonstrated value not only in meeting its original objectives but also in broader educational and institutional contexts. Its structured, incremental design provides a flexible framework for HPC training that can be adapted to varied settings and participant backgrounds. Beyond equipping students with technical skills, the model contributes to institutional capacity building, raises awareness of HPC, and fosters collaboration across universities.

Undergraduate participation where HPC exposure is limited: The model lowers barriers to entry and offers a practical pathway into HPC education, particularly in regions where HPC has yet to be embedded in curricula. By enabling students to engage with HPC concepts earlier in their studies, it expands the pipeline of future practitioners and researchers.

Accelerated skill gain across heterogeneous cohorts: The tiered progression accommodates students with widely differing levels of prior knowledge. Even participants who do not progress to the international stage acquire meaningful skills and confidence, ensuring that the benefits extend across the entire cohort.

Motivation through international pathways: The opportunity to compete internationally and attend ISC High Performance has proven to be a powerful motivator. It encourages individual learning, elevates the profile of HPC within institutions, and strengthens institutional support for continued participation.

Collaborative problem-solving: Teams are required to design, configure and benchmark working systems under time and resource constraints. This develops technical competence alongside vital soft skills, including communication, coordination and leadership.

Talent pipeline for research and industry: Graduates of the programme move into computational research, engineering and data-intensive industries with operational experience that shortens the transition from academic training to professional practice. This reinforces the national HPC talent pipeline and supports broader research and innovation goals.

A defining feature of the model is its emphasis on practical, hands-on training. Participants move beyond theory to active engagement in system design, configuration and benchmarking, gaining both conceptual understanding and operational proficiency. These skills are directly transferable to academic research, industry roles and national HPC initiatives, ensuring that the benefits of the programme extend well beyond the competition itself.

7 REFLECTION

7.1 Challenges

Running a competition in a resource-constrained environment presents a unique set of challenges. Students often enter with little prior exposure to high-performance computing, and many have limited awareness that HPC even exists as a career path. Although this lack of awareness was the main motivation for launching the outreach initiative, it also means that each cohort begins with a steep learning curve, with uneven levels of preparation between teams.

Another challenge lies in the long-term sustainability of the pipeline. Although many students benefit greatly from training and competition, only a subset remain connected to the broader HPC ecosystem after completing their studies. Others, despite their initial enthusiasm, disappear from the pipeline, highlighting the difficulty of maintaining momentum without structured follow-up opportunities or consistent mentorship.

The time available for facilitators to interact directly with students is also limited. Throughout the program, facilitators typically have only about a month of face-to-face engagement: approximately one week in Round 1, one week in Round 2, one week in the United States, and one week preparing at CHPC. This does not include the competition itself. The constraint limits the depth of mentoring that is possible and makes it difficult to provide extended support to students who fall behind.

Within competition itself, the disparities in performance are stark. The rankings are often predictable from the outset, with a handful of strong teams steadily improving year after year, while others struggle from the beginning. This gap reflects broader systemic issues: unequal access to local computing resources, uneven levels of supervision and mentorship, and institutional differences in technical capacity. These disparities make it difficult to ensure a level playing field between all participants, despite the competition's efforts to do so.

7.2 Highlights

Despite the difficulties of working in a resource-limited context, the competition has achieved notable successes that demonstrate both its impact and its replicability. First, the programme has received strong institutional and industry support. Sustained funding from the CHPC, combined with international collaborations, has enabled South Africa to field competitive teams year after year. Partnerships with TACC and Dell Technologies have provided technical expertise and cutting-edge competition hardware. The ISC-HPC has also supported the effort by reserving a competition slot for the South African SCC team, ensuring a competition pipeline and consistent exposure on the global stage. These collaborations highlight the importance of external support: emulating this model elsewhere would likewise require investment and commitment from pivotal external stakeholders.

The achievements of participants further illustrate the program's impact. Former students now work in HPC and adjacent fields, both in South Africa and abroad, including several of the authors of this paper. Others have gone on to build lasting communities of practice, such as the University of the Witwatersrand's SIG HPC [1, 6], extending the competition's influence into sustained academic and professional networks. South African teams have earned repeated accolades at ISC, including multiple top-three placements across consecutive years, underscoring the competitiveness of the training model.

Underlying these outcomes is a training curriculum that has been refined over more than a decade of practice. The curriculum integrates best practices such as distributing an introductory data packet with YouTube tutorials prior to the event, which allows students to become familiar with fundamental concepts in advance. During the training sessions, facilitators deliberately design hands-off practicals to encourage peer problem-solving, freeing up time to provide targeted support to teams that are struggling. At the same time, experience has shown that the curriculum's fast pace can leave some students behind, and facilitators are often stretched too thin to fully close these gaps. Nonetheless, the iterative improvements have yielded a repeatable, structured model for rapid HPC training, one that has consistently elevated students from little prior exposure to international competitiveness in just a matter of weeks.

7.3 Lessons Learned

Several broad lessons have emerged from more than a decade of running the CHPC SCC, many of which are applicable to similar initiatives elsewhere. The most consistent finding is that hands-on, competitive formats are uniquely effective. The act of building, breaking, and fixing real systems under time pressure develops confidence and technical maturity much faster than classroom teaching alone. Students remember not the instructions they are given, but the problems they solve.

A second lesson is that student preparation is never uniform. Effective programs must recognize this reality and design scaffolding to raise the floor. Introductory materials, structured mentoring, and targeted one-on-one guidance allow students with less background to contribute meaningfully while still challenging the strongest participants.

Third, access to resources matters. Cloud platforms provide a useful entry point, but they come with limitations in reliability, accessibility, and longevity. Long-term success depends on giving students consistent access to real HPC environments. The 2024 introduction of an OpenHPC virtual lab [4], which coincided with the South African team's return to the top three at ISC, underscored how impactful this access can be.

Finally, sustainability requires more than annual training cycles. Continued funding, active alumni networks, and strong institutional partnerships are essential to keep the pipeline vibrant. Alumni who remain engaged, as mentors, organizers, or professionals in HPC, extend the impact well beyond a single competition.

Perhaps the deepest lesson is philosophical: HPC expertise cannot be handed down fully formed. Mastery comes only through repeated attempts, failures, and refinements. The competition succeeds not because it teaches everything, but because it channels student passion into a structured environment where persistence leads to growth. The best students ultimately learn more on their own than they ever could from direct instruction, and the SCC gives them the spark to begin that journey.

7.4 Future Work

Future plans for the CHPC SCC are shaped by years of hands-on engagement, reflective practice, and the continuous stream of ideas sparked while designing, mentoring, and iterating in real-world HPC training environments.

While the vision continues to evolve, this account serves as a retrospective - capturing the scaffolding, spirit, and lessons of a formative era. Leadership of the SCC initiative has since been passed on, ensuring that new voices and fresh perspectives carry the momentum forward.

8 REPRODUCIBILITY AND RESOURCES

The CHPC SCC was not originally designed as a reproducible turn-key solution for other HPC centres, however, many elements of the model can be adopted elsewhere. Over the years, consistent documentation has been difficult to maintain, particularly as facilitators moved on to other roles, leaving an incomplete archival record. Still, several resources remain accessible: the University of the Witwatersrand's University HPC Special Interest Group (SIG HPC) has documented their student-led training pipeline that prepares teams for SCC and international competitions [1, 6], and video content created for the 2020 competition during the COVID-19 pandemic (available on CHPC's YouTube channel) provides a concrete snapshot of training delivery and expectations that can be adapted by others.

Reproducing the technical infrastructure, modest clusters or cloud resources, standard Linux/MPI stacks, and familiar benchmarks such as HPL and HPCG, is relatively straightforward. The more difficult component to reproduce is the facilitators. At CHPC, a team of full-time engineers took on the role of facilitators during the competition: they planned, coordinated logistics, delivered training, and mentored students, from the fundamentals to competing in Germany. This level of engagement was made possible by official time allocated to the competition, ensuring that professional expertise was consistently available to participants.

For centres considering a similar programme, the key insight is that reproducibility depends less on access to hardware or benchmark codes, and far more on sustained investment in human resources. Allocating time for experienced engineers to serve as facilitators is essential to replicating the impact of the CHPC SCC.

9 CONCLUSION

For more than a decade, the CHPC Student Cluster Competition has reshaped HPC outreach and education in South Africa, demonstrating that rapid technical upskilling and international competitiveness are possible even in resource-constrained environments. By combining focused, resource-efficient training with collaborative, high-stakes competition, the programme has cultivated a generation of capable practitioners and innovators.

Beyond its national impact, the CHPC SCC presents a scalable model for HPC education worldwide. Its emphasis on technical rigor, teamwork, and inclusive opportunity offers a proven framework that other regions can adapt to build their own pipelines of HPC talent and strengthen participation in the global research community.

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