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Integrating ecosystems: The synergistic effects of digital innovation hubs on start-up growth

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Background: South Africa faces significant socio-economic challenges, with unemployment rate. This highlights the need for economic strategies to generate employment, and start-ups are crucial in this context, as they foster innovation, create jobs and increase competitiveness.

Aim: The study aims to investigate how digital innovation hubs (DIHs) influence start-up growth, focusing on their roles and functions.

Setting: The research is set within the context of DIHs in Africa, specifically examining the 12 DIHs established under the AEDIBNET programme.

Methods: A qualitative methodology was employed, using semi-structured interviews with six DIH managers and 28 entrepreneurs or start-up founders.

Results: Supporting start-up growth, holistic development support and integrated ecosystem enhancement by DIHs emerged as key themes. These factors foster a conducive environment for innovation and sustained growth.

Conclusion: Digital innovation hubs play a crucial role in supporting start-up growth by providing comprehensive and integrated support systems. Their functions collectively enhance start-up growth.

Contribution: This study fills a critical gap in the existing literature on DIHs, offering empirical insights into their impact on start-up growth within the African context. The findings provide valuable implications for policymakers, practitioners and researchers aiming to foster the growth of start-ups. Additionally, the study integrates and expands upon knowledge spillover theory, institutional theory and cluster theory. It demonstrates how DIHs facilitate knowledge sharing, provide formal support structures, foster informal networks, and create and sustain entrepreneurial clusters.

Keywords: digital innovation hub; DIH ecosystem; synergistic effects; start-ups; institutional theory; cluster theory; knowledge spillover theory; qualitative study.

Introduction

South Africa faces numerous socio-economic challenges, with high unemployment rates being one of the most pressing issues, currently at 32.9% as of the first quarter of 2024 (Statistics South Africa 2024). This highlights the critical need for economic development strategies to generate employment and drive growth. Promoting start-ups is one such strategy, as they are key drivers of economic development and growth (Ács, Szerb, & Lloyd 2018; Kumalo & Kaseeram 2019; Matyas et al. 2019; Meyer & Synodinos 2019; Urbano, Aparicio & Audretsch 2019). However, despite the recognised potential of start-ups to drive economic growth, their impact remains largely unfulfilled in South Africa due to a sluggish economy and the numerous challenges that start-ups face in their early stages (Eresia-Eke et al. 2019; Hlongwane & Daw 2023; Msimango-Galawe & Urban 2019; Ntshwanti 2022). Start-ups in Africa face numerous challenges, including limited access to funding, inadequate infrastructure, and a lack of mentorship and support networks (Hausberg & Korreck 2021). Digital innovation hubs (DIHs) aim to address these challenges by providing a comprehensive support system that integrates various services and resources essential for start-up success (Kalpaka et al. 2020). Given the challenges faced by start-ups, it is imperative to explore and understand the mechanisms through which DIHs can enhance start-up growth.

The existing body of research on DIHs has primarily focused on regions such as Europe and the United States (US). While the DIHs are still under-researched and under-utilised even within Europe and the US (Georgescu, Avasilcai & Peter 2021), there is a need to explore them within the

context of South Africa and Africa as the interest and emergence of DIHs in Africa have sparked a need for a dedicated investigation. This research aims to unravel the actual benefits that DIHs bring to the African context and how they exert influence on start-up growth.

The call for validation in understanding the benefits that start-ups derive from DIHs is driven by several crucial factors. Firstly, as DIHs are a relatively new concept, there is a need to establish empirical evidence and concrete insights into their actual impact on start-ups, especially within the unique context of South Africa and Africa at large. Secondly, validation is important because it adds credibility to claims about the positive influence of DIHs on start-up growth, substantiating the theoretical frameworks and expectations surrounding the benefits start-ups are expected to gain from engaging with DIHs. Validation is crucial for multiple stakeholders. For researchers and academia, it ensures the rigour and reliability of their findings, advancing knowledge in entrepreneurship and innovation. For policymakers, understanding the validated benefits of DIHs can inform strategic decisions and policies to foster a supportive ecosystem for start-ups. For entrepreneurs and start-ups, validation provides assurance and clarity about the tangible advantages of collaborating with DIHs, guiding their strategic decisions and investments in innovation. Essentially, validation becomes a cornerstone for informed decision-making across academic, policy and entrepreneurial ecosystems.

This article explores the multifaceted roles and impacts of DIHs on start-up growth, examining how their integrated functions create synergistic effects that significantly enhance start-up growth in South Africa. By providing empirical insights into how integrated ecosystem support can enhance start-up growth among African start-ups, this research seeks to fill a critical gap in the existing literature and offer valuable implications for policymakers, practitioners and researchers interested in enhancing the growth of start-ups in developing regions.

Literature review

Start-ups

Start-ups are young entrepreneurial companies that are less than 5 years old and are a subgroup of small and midsize enterprises (SMEs) (Aldianto et al. 2021). They differ from established companies in terms of organisational structure, leadership, reactions to the environment, available resources and the internal context in which they operate. While some SMEs are start-ups, the latter do not remain SMEs forever as they have a high growth trajectory. Garg and Gupta (2022) further extend that a start-up is a company that is run by an entrepreneur to develop and validate a scalable business model. Start-ups rapidly iterate and make changes in the development of their products (Miranda & Borges 2019) and it is in their agility nature that they innovate.

In South Africa, while there is no promulgated start-up policy, a *South Africa Start-up Act* position paper exists (*South Africa Start-up Act* 2021). For a company to be classified as a start-up, the *South Africa Start-up Act* has several qualifiers and exclusions which include a newly established business that is less than 5 years old, has an annual turnover of less than R100 million, does not pay dividends or share of profits, and has not done so in the past, has a focus on the development, production and commercialisation of innovative products or services with a clear technology component, is not a result of a merger or split and operates in certain sectors of the economy. Exclusions are companies that trade in movable property, banking, insurance and money lending businesses, excluding the development of technology solutions around these, advisory services in the financial sector, excluding the development of technology solutions around these, gambling industry, excluding the development of technology around this industry, and trading and operating in the manufacture of liquor, tobacco, arms and ammunition, excluding the development of technological solutions around these.

The start-up community consists of entrepreneurs and different partners, including DIHs, business incubators and accelerators, technology-based-incubators (TBIs), investors, funding institutions, service providers who provide different services, universities and research organisations, and corporates that bring together the resources, funders, investors, infrastructure, networking, marketing, experts, talent, among others, which help in the growth and sustainability of start-ups (Garg & Gupta 2022).

For this study, start-ups are considered as young entrepreneurial companies that are less than 5 years old (Aldianto et al. 2021) that develop and validate a scalable business model (Garg & Gupta 2022) through rapid iteration and innovation (Miranda & Borges 2019) and operating in identified growth areas (*South Africa Start-up Act* 2021).

The role of start-ups in economic development has been emphasised by numerous studies (Audretsch & Belitski 2017; Bosma & Kelley 2019). Start-ups are known for their agility and ability to innovate, which enables them to respond quickly to market changes and create new products and services that drive economic growth (Audretsch & Belitski 2017). However, the high failure rate of start-ups highlights the need for supportive environments that can provide the necessary resources and guidance to help them succeed (Hausberg & Korreck 2021).

Digital innovation hubs

The emergence of DIHs in recent times as a vehicle that enhances start-up growth has opened a new area for study. Emerging as vital institutions in fostering entrepreneurship, particularly by facilitating the growth and development of start-ups (Vakirayi & Van Belle 2020), DIHs originated as a policy instrument by the European Commission (Maurer 2021). They aim to promote digital transformation and innovation across various sectors by providing a comprehensive suite of services, including technical expertise, training, access to funding and networking

opportunities (Kalpaka et al. 2020; Ujwary-Gil & Godlewska-Dzioboń 2022).

Functions of digital innovation hubs

Digital innovation hubs perform several key functions that are essential for the growth and sustainability of start-ups. One of the primary functions of DIHs is the 'test before invest' capability, which provides start-ups with access to technical expertise and experimentation facilities (Asplund, Macedo & Sassanelli 2021). This function allows start-ups to prototype and validate their innovations before making significant investments, thereby reducing the risk associated with new ventures (Kalpaka et al. 2020). Additionally, DIHs offer skills and training programmes to help start-ups build the necessary competencies to adopt and implement new digital technologies effectively (Sassanelli et al. 2021). These training programmes are crucial in ensuring that start-ups have access to the latest knowledge and skills required to stay competitive in a rapidly evolving digital landscape.

Another critical function of DIHs is providing support to secure investments. Digital innovation hubs assist start-ups in finding and accessing funding opportunities from various sources, including venture capitalists, financial institutions and government grants (Kalpaka et al. 2020). This financial support is vital for the growth and scalability of start-ups, enabling them to transition from the ideation phase to market readiness. Furthermore, DIHs facilitate networking and ecosystem integration by connecting start-ups with a broad range of stakeholders, including industry experts, academic institutions and corporate partners (Sassanelli et al. 2021). This networking function fosters collaboration, knowledge exchange and strategic partnerships, which are essential for the innovation and long-term success of start-ups (Kalpaka et al. 2020). By integrating these various functions, DIHs create a supportive ecosystem that significantly enhances the growth of start-ups.

Digital innovation hub ecosystem

Digital innovation hubs play a crucial role in start-up growth by providing a structured environment that fosters innovation in start-ups (Rudawska 2022). Acting as central nodes within the innovation ecosystem, DIHs offer a range of services essential for start-up development and success, including access to advanced technological infrastructure, expert mentorship, funding opportunities and networking platforms that connect start-ups with key stakeholders such as investors, academic institutions and industry leaders (Kalpaka et al. 2020; Rowan et al. 2022). These integrated functions address various challenges faced by start-ups, enhancing their ability to innovate and compete in the market. The DIH ecosystem facilitates seamless interaction between different actors within the entrepreneurial landscape, providing a collaborative platform for start-ups to engage with partners, including other start-ups, established companies, research institutions and government bodies (Crupi et al. 2020). This interaction is crucial for knowledge exchange, a key driver of innovation and enables start-ups to leverage the collective expertise and resources of the ecosystem, accelerating their growth and development (Asplund et al. 2021). Networking opportunities provided by DIHs help start-ups establish strategic partnerships and gain market access, critical for long-term success (Sassanelli et al. 2021). Despite the significant role of DIHs, there is limited empirical research on their specific impact in the African context, with existing studies primarily focusing on European and American settings (Georgescu et al. 2021). The DIH ecosystem includes diverse stakeholders such as government, large companies, start-ups, SMEs, private investors, accelerators, incubators, entrepreneurs, universities, research organisations, specialised services, mentors and clusters, all connected and reinforced by supportive relationships and essential resources like technology and intellectual resources (Rudawska 2022). This one-stop shop helps companies and start-ups become more competitive in their business processes, products, or services using digital technologies by providing access to technical expertise and experimentation.

Digital innovation hubs outside Africa

Digital innovation hubs have been extensively studied in regions such as Europe and the US, where they play a pivotal role in fostering innovation and economic growth (EU 2020; Hervás Oliver 2021; Stojčić 2021). In Europe, DIHs were established as a policy instrument by the European Commission to support the digital transformation of industries and enhance the competitiveness of SMEs (Kalpaka et al. 2020). As of 2019, Europe was home to a total of 519 DIHs with 483 located in EU member states. Among these, 360 DIHs were already operational, while 159 were in the process of preparation (Teixeira & Tavares-Lehmann 2022). The European DIH ecosystem is designed to facilitate collaboration between various stakeholders, including industry leaders, academic institutions and government bodies, thereby creating a robust environment for innovation (Crupi et al. 2020).

In the USA, DIHs have similarly been instrumental in driving technological innovation and supporting the growth of start-ups. The American approach to DIHs often emphasises the importance of commercialisation and rapid market entry, with a strong focus on providing start-ups with the necessary resources to scale their operations quickly. This includes access to venture capital, mentorship from experienced entrepreneurs and partnerships with leading technology firms (Hausberg & Korreck 2021). The success of DIHs in the US is largely attributed to their ability to integrate diverse elements of the innovation ecosystem, creating synergies that enhance the entrepreneurial capabilities of start-ups (Georgescu et al. 2021).

Digital innovation hubs within Africa

Digital innovation hubs have become increasingly important in the African context, where they serve as crucial platforms for fostering entrepreneurship and innovation (Dada & Van Belle 2023). The emergence of DIHs in Africa is a response to the continent's unique socio-economic challenges, such as

high unemployment rates and limited access to technological infrastructure. These hubs provide essential services that support the development and growth of start-ups, including access to advanced technological tools, mentoring, funding and strategic networking opportunities (AfriLabs & Briter Bridges 2019). By offering a comprehensive support system, DIHs help mitigate the barriers that African start-ups typically face, thus enhancing their chances of success and sustainability (Jiménez & Zheng 2021).

The concept of the DIH, therefore, is meant to be a place of connection and interaction between entrepreneurs and other stakeholders. The notable increase in DIHs throughout Africa has been remarkable and these act as centres for technology start-ups, entrepreneurs and innovators (Friederici 2019). It is argued that little research has been done on what DIHs do for African digital entrepreneurs (Friederici 2019). Following this, Atiase, Kolade and Liedong (2020) conducted case studies in Nigeria, South Africa, Kenya and Uganda to contribute towards the understanding and contribution of hubs on the continent. Research conducted in Tanzania revealed that while innovation hubs have the potential to empower youth through collaborative knowledge creation and innovation, their effectiveness in fostering entrepreneurship fell short (Mwantimwa et al. 2021).

Literature shows Smidt and Jokonya (2022) using the term DIH in South Africa with their view of DIHs as competence centres that provide the core element of operations and technical expertise, facilities and infrastructure. The model of Smidt and Jokonya (2022) had government, academia and industry as stakeholders that provided support to the farmers through digital transformation. One of the critical roles of DIHs in Africa is to act as a bridge between start-ups and various stakeholders within the innovation ecosystem. This includes connecting start-ups with investors, corporations, academic institutions and the government (Friederici 2019; Jiménez & Zheng 2021). By facilitating these connections, DIHs enable start-ups to access a wide range of resources and expertise that are crucial for their growth and development. For example, the African-European Digital Innovation Bridge Network (AEDIBNET) has established multiple DIHs across several African countries, providing start-ups with a platform to engage with international partners and leverage global best practices (Kalpaka et al. 2020). This cross-border collaboration is essential for supporting the growth of start-ups in Africa.

Despite the growing presence and impact of DIHs in Africa, there remains a significant gap in the empirical research that explores their specific contributions to start-up growth within the continent. Much of the existing literature has focused on the role of DIHs in developed regions like Europe and the USA, with relatively less attention given to the African context (Georgescu et al. 2021). This lack of research highlights the need for more in-depth studies that examine how DIHs operate in Africa, the unique challenges they address and their overall impact on start-up growth. Such research is crucial for informing policy decisions and developing strategies that can further enhance the effectiveness of DIHs in promoting innovation and economic development in Africa (Vakirayi & Van Belle 2020).

Theoretical framework

The study uses the perspectives of knowledge spillover theory, institutional theory and cluster theory to explore DIHs. According to knowledge spillover theory, companies in the same locality benefit from shared technology and development, leading to increased entrepreneurship (Ács et al. 2009). The dissemination of knowledge among individuals and organisations provides entrepreneurs with valuable insights, technological advancements and effective business strategies, fostering innovation and prompting the creative application of new ideas and technologies. Co-location with selective entry and structured interactions between start-ups in DIHs optimise their proximities (Madaleno et al. 2022).

Institutional theory explains the interrelationships and coordination between stakeholders in DIHs and start-up growth (Dubey et al. 2019). DiMaggio and Powell (1983) in their seminal article argued that organisations are driven more by efficiency needs than competition, resulting in homogeneity. This theory supports the importance of DIHs for start-up growth. Start-ups within a DIH often mimic successful peers, gaining legitimacy (Covin & Miller 2014). This can explain similar collaborative strategies in business incubators and DIHs. Additionally, institutional theory suggests that the desire to become entrepreneurs is shaped by the living context (Dheer 2017).

In economic clusters, cluster theory is used where geographical location gives new companies a competitive advantage because of co-location (Audretsch & Belitski 2017; Spigel & Harrison 2018). This was earlier explained by Spigel (2017) who posited that companies may share economic infrastructure like equipment, buildings and fibre Internet that enables knowledge transfer and sharing. Digital innovation hubs within the institutional dynamics are, therefore, considered to be important in the development of entrepreneurs and the achievement of high entrepreneurial activity (EA).

Cluster theory is used in economic clusters where geographical location gives new companies a competitive advantage due to co-location (Audretsch & Belitski 2017; Spigel & Harrison 2018). Companies may share economic infrastructure such as equipment, buildings and fibre Internet, enabling knowledge transfer and sharing (Spigel 2017). Digital innovation hubs within these institutional dynamics are crucial for developing entrepreneurs and achieving start-up growth. The principles of cluster theory, the presence of other companies, knowledge spillover and knowledge creation are used to develop DIHs, fostering entrepreneurship through knowledge sharing and collaboration (Spigel & Harrison 2018).

There are strong links between cluster, knowledge spillover and institutional theories, as they all focus on shared benefits within an ecosystem. Cluster theory emphasises industrial benefits and co-location, knowledge spillover theory highlights shared technology and development, and institutional theory underscores systemic interaction. Together, these theories illustrate the interconnectedness and location of DIHs and how they support start-up growth.

Research methods and design

This study aims to investigate how DIHs influence start-up growth and seeks to uncover how a DIH as an integrated ecosystem can enhance the success and sustainability of start-ups.

This study's main research objective is *to investigate the influence of DIHs on the growth of start-ups*. To comprehensively address this primary objective, the study introduces two secondary research objectives aimed at providing a nuanced exploration of the multifaceted relationships within DIH and how the functions of DIHs interact and intersect to shape the growth of start-ups:

- RO_1: *To explore the functions of DIHs*.
- RO_2: *To investigate the interaction of the functions of DIHs and their influence on the growth of start-ups*.

Based on the research objectives, the following research questions are formulated to guide the study on how DIHs influence the growth of start-ups:

- RQ_m: *What is the influence of DIHs on the growth of start-ups*?

In exploring and answering the main research question, the study will answer the following secondary research questions:

- RQ_1: *What functions of DIHs influence the growth of start-ups?*
- RQ_2: *How do the functions of DIH interact and influence the growth of start-ups?*

In social research, the choice of methodology often sparks debate. Park and Park (2016) suggest that the methodology should adequately describe, explain and explore the research matter, with the research objective determining the research design (Walliman 2017). A qualitative methodology is relevant for understanding the influence of DIHs on start-up growth, as it provides insights into why things are the way they are in the social world (Al-Ababneh 2020). Consequently, this study employed a qualitative approach. Data were collected through semi-structured online interviews.

Population and sampling strategy

The study focused on DIH or programme managers and entrepreneurs or start-up founders associated with DIHs. Start-ups included were those involved with a DIH within the last 5 years, aligning with the definition of start-ups as young entrepreneurial companies less than 5 years old (Aldianto et al. 2021). Understanding the perspectives of both support recipients (entrepreneurs or start-up founders) and providers (DIH or programme managers) is crucial for comprehending how DIHs influence start-up growth. Thus, the sample included DIH managers and start-up founders.

The population of DIH or programme managers comprised all managers from the 12 DIHs in Africa under the AEDIBNET programme, with no exclusions. For entrepreneurs or start-up founders, the sample was drawn from those at the Tshimologong Digital Innovation Precinct in South Africa, the sole DIH under the AEDIBNET programme in the country. These entrepreneurs or start-up founders were randomly selected based on their current residence at Tshimologong Precinct or their participation in a support programme such as incubation or acceleration within the last 5 years. This selection was made for convenience and accessibility.

Sampling is crucial in academic research and is part of every kind of empirical research (Haenssgen 2019; Kumar 2019). The study employed purposive sampling, a method characterised by the deliberate selection of participants who share a common purpose or represent a specific thematic focus in the research domain (Cassell 2015; Creswell & Poth 2018; Flick 2019). This sampling strategy aligns with the research objective of obtaining in-depth insights from individuals closely involved with DIH activities, ensuring that the selected sample is both relevant and representative of the population central to the study's goals.

The deliberate choice of purposive sampling aimed to capture nuanced perspectives and experiences of DIH or programme managers and entrepreneurs or start-up founders directly engaged with DIHs. This method is favoured for its flexibility, allowing for the intentional inclusion of participants with diverse viewpoints, ultimately contributing to a comprehensive understanding of the influence of DIHs on start-up growth. The decision to use purposive sampling considered the study's specific context, aiming for depth and specificity in participant selection.

The study aimed to capture insights from one representative per DIH and resulted in a sample size of 6 out of the 12 DIHs under consideration, achieving a 50% participation rate. The response rate was influenced by some DIH or programme managers citing the ongoing establishment of their hubs and the absence of operational activities as reasons for non-participation. Additionally, the study included a second sample of entrepreneurs or start-up founders who had participated in business incubation or acceleration at Tshimologong DIH in Johannesburg over the past 5 years. Out of a targeted sample of 79 entrepreneurs or start-up founders, 28 participated, resulting in a 35% participation rate. Challenges in the outreach process included 11 bounced emails and a subset of non-responsive potential participants,

possibly due to the start-ups no longer existing or other undisclosed reasons. These challenges reflect the dynamic nature of the start-up landscape and the varying circumstances influencing research engagement. Despite these obstacles, the study obtained valuable insights from a significant portion of the intended sample, contributing important perspectives to the exploration of DIHs and their influence on start-up growth.

Research instrument

The primary research instrument for this study was semi-structured interviews, which allowed for an in-depth exploration of the research questions and provided flexibility to delve deeper into specific areas of interest as they emerged. The semi-structured interview guide included questions designed to gather detailed information about the key functions of DIHs, their interactions and their impact on start-up growth. Structured around the main research objectives, the guide had sections dedicated to exploring the roles and functions of DIHs, the interaction of these functions and their influence on start-up growth. Open-ended questions were used to encourage participants to share their experiences and perspectives in their own words, providing a comprehensive understanding of the subject matter (Sassanelli et al. 2021).

Data analysis

Data collected from the semi-structured interviews were analysed using thematic analysis. This method involved identifying, analysing and reporting patterns (themes) within the data. The process began with transcribing the interview recordings verbatim, followed by a thorough reading of the transcripts to become familiar with the data (Asplund et al. 2021). Coding was then performed to organise the data into meaningful groups. Initial codes were generated based on the research questions and objectives, and these codes were iteratively refined and categorised into broader themes. The thematic analysis allowed for the identification of key themes that capture the essence of participants' experiences and perspectives regarding the influence of DIHs on start-up growth (Georgescu et al. 2021).

The final step involved interpreting the themes in the context of the research questions and objectives. This interpretation sought to provide a nuanced understanding of the multifaceted roles of DIHs and their impact on start-ups, offering valuable insights for policymakers, practitioners and researchers interested in fostering entrepreneurial ecosystems in developing regions.

Trustworthiness

In qualitative research, trustworthiness is crucial for evaluating credibility, transferability, dependability and confirmability, ensuring that findings reflect participants' experiences and perspectives with a transparent and rigorous research process. Credibility was established through triangulation, collecting data from multiple sources such as DIH or programme managers and entrepreneurs or start-up founders, and conducting member checking to ensure an accurate representation of their experiences (Shenton 2004). Transferability was addressed by describing the research context and start-ups, enabling readers to determine the applicability of findings to other settings, and using a purposive sampling strategy to select participants with rich, relevant experiences. Dependability involves maintaining data stability over time and conditions through an audit trail documenting the research process from data collection to analysis, ensuring transparency and replicability (Lincoln & Guba 1985), and using semi-structured interviews for a systematic approach to data collection (Patton 2002). Confirmability was ensured through reflexivity, where the researcher reflected on biases and their impact on the research (Lincoln & Guba 1985), supported by an audit trail and peer debriefing, with the study supervisor reviewing the research process and findings to check interpretations and conclusions (Shenton 2004).

Ethical considerations

Ethical clearance to conduct this study was obtained from the Research Ethics Committee at the University of Pretoria (reference no.: EMS236/22). The researcher ensured that ethical standards were maintained throughout all stages of the research; before, during and after data collection as emphasised by Wa-Mbaleka (2019), who asserts that ethical considerations extend beyond data collection.

Results

This section presents the empirical evidence, detailed results analysis and interpretations from the study. The data analysis is divided into three parts, identifying and discussing the major themes that emerged from the research questions during the interviews and literature review. Each theme is explored in-depth to understand how DIHs influence start-up growth.

Supporting start-up growth and success

Theme one, *supporting start-up growth and success*, emerged, relating to the main research objective of investigating the influence of the DIHs on the EA of start-ups. This theme addresses the main research question: 'What is the influence of DIHs on the EA of start-ups?' It highlights the crucial role and influence that DIHs have on nurturing start-up growth and success. This theme captures how DIHs accelerate the development of start-ups by providing essential resources, mentoring and support that enhance their viability and operational capabilities. Digital innovation hubs facilitate the transition from ideation to market-ready products, contributing to the overall growth and sustainability of start-ups. Digital innovation hubs offer a structured environment with access to critical infrastructure, funding opportunities and expert guidance, which helps start-ups navigate early-

stage development challenges, accelerate growth and improve long-term success prospects.

As one DIH manager noted:

> 'Digital innovation hubs … play a very huge role … in impacting how start-ups are created and how they can get into the economy. My thinking has always been around how do we quicken start-ups' ability to gain market access?' (M1, Male, Bachelors Degree)

Similarly, an entrepreneur commented, 'The DIH provided us with the infrastructure and connections that were crucial for our initial growth phase' (E2, Male, Doctoral Degree). Another entrepreneur added, 'Without the mentorship and funding access from the DIH, we wouldn't have been able to sustain our early operations' (E3, Male, National Diploma).

Both DIH managers and entrepreneurs or start-up founders recognise the critical role DIHs play in supporting start-up growth and success. Digital innovation hubs provide a crucial platform that aids in resource allocation, expert access and strategic planning, which collectively fast-track the commercialisation process and enhance the start-ups' market presence. This synergy between the DIH's offerings and start-up needs creates a conducive environment for sustained growth and competitive advantage.

Holistic development support by digital innovation hubs

The second theme, *holistic development support by DIHs*, emerged, relating to the secondary research objective of exploring the main functions of DIHs. This theme addresses the secondary research question one: 'What main functions of DIHs influence the EA of start-ups?'. This theme captures how DIHs serve as comprehensive support platforms that nurture start-up growth through multifaceted assistance. These services are essential for developing market-ready products, creating financially sustainable models, and appealing to investors and customers. It identified several key functions of DIHs that significantly impact start-up growth. These include the 'test before invest' function, which allows start-ups to refine their technologies and business models efficiently before scaling up operations (Asplund et al. 2021).

Additionally, DIHs provide skills and training, funding support, and foster ecosystem and networking opportunities. These functions collectively enhance the practical and market viability of start-ups by ensuring they focus on developing market-ready products, financially sustainable models and viable offerings that appeal to investors and customers (Kalpaka et al. 2020). A DIH manager highlighted, 'The focus on the viability of start-ups is extremely important because viability determines how far the start-up can go or which direction the start-up can take?' (M1, Male, Bachelors Degree). Another added, 'Digital innovation hubs facilitate prototyping which is crucial for start-ups to test their innovations in real market conditions' (M3, Male, Bachelors Degree). An entrepreneur also emphasised, 'Each function of the DIH contributes uniquely but it's their combination that has truly transformed our business' (E10, Male, Bachelors Degree). Another entrepreneur stated, 'The training sessions provided by the DIH have been invaluable in helping us develop the skills necessary to navigate the competitive market' (E4, Male, Masters Degree).

Both DIH managers and entrepreneurs or start-up founders highlight the importance of the fundamental functions provided by DIHs, including critical infrastructural support and essential services that facilitate rapid growth and integration into the broader business ecosystem. Networking emerges as a key function, where DIHs act as catalysts for creating valuable connections that can lead to investment opportunities and market expansion. These functions are integral in transforming nascent ventures into robust businesses capable of navigating complex markets.

Integrated ecosystem enhancement by digital innovation hubs

The last theme, *integrated ecosystem enhancement by DIHs,* emerged, relating to the secondary research objective of investigating the interaction of the main functions of DIHs and their influence on start-up growth. This theme addresses the secondary research question two: 'How do the functions of DIHs interact and influence the growth of start-ups?'. This theme examines how DIHs create a synergistic environment that promotes start-up growth by integrating various support functions such as mentorship, funding access, and technical support and how the interconnected nature of these functions enhances start-up growth. By integrating various functions such as mentorship, funding access and technical support, DIHs ensure start-ups receive comprehensive support tailored to their needs, facilitating faster growth and development.

This synergy promotes innovation and resilience within the entrepreneurial ecosystem, enabling start-ups to achieve sustainable growth. One DIH manager commented, 'Digital innovation hubs improve entrepreneurial activity by providing a one-stop shop that promotes sector-agnostic innovation' (M2, Male, Masters Degree). An entrepreneur reflected, 'The synergy between networking, funding, and mentoring has propelled our start-up to new heights' (E15, Male, Honours Degree). Another entrepreneur noted, 'The combined support functions of the DIH have created a robust foundation for our growth, making it easier to tackle challenges as they arise' (E5, Male, Bachelors Degree).

Both perspectives from the DIH managers and entrepreneurs or start-up founders emphasise the interconnected nature of DIH functions, ranging from networking, funding and infrastructure, to mentoring and how these collectively enhance the growth of start-ups and their development. This integration fosters a holistic support system that not only addresses immediate needs but also prepares start-ups for future challenges. Through these combined efforts, DIHs ensure that start-ups not only survive but thrive in competitive environments.

These themes illustrate the multifaceted roles of DIHs in supporting start-ups and underscore their critical position

within start-up growth. By providing structured and strategic support, DIHs enable start-ups to navigate complex challenges, leverage new opportunities, and ultimately contribute to dynamic and sustainable economic growth in Africa.

Discussion

The results of this study indicate that DIHs play a crucial role in supporting and enhancing the growth of start-ups. Through functions such as providing critical infrastructure, facilitating networking, offering essential services and integrating start-ups into broader ecosystems, DIHs contribute significantly to the growth and sustainability of start-ups (Crupi et al. 2020; Kalpaka et al. 2020). Acting as coordinators, DIHs bring together different stakeholders (industry, university, public and government) with companies, notably start-ups, facilitating essential networking opportunities (Kalpaka et al. 2020; Sassanelli et al. 2021). With the DIH acting as a coordinator of an ecosystem, the study reinforces the knowledge spillover theory by demonstrating how DIHs facilitate the unintentional flow of knowledge among start-ups, leading to innovation and increased entrepreneurship (Audretsch & Belitski 2017; Ferreira, Ratten & Dana 2017).

While the study presents DIHs as crucial for supporting and enhancing start-up growth, there are limitations and challenges associated with DIHs due to heavy reliance on DIHs leading to start-ups becoming overly dependent on external support, which might inhibit their ability to operate independently once the support is withdrawn. Abrahams (2020) highlights this risk of creating dependency among start-ups, which may struggle to sustain themselves without continuous external support. Despite this risk, this study, supported by the three main themes that emerged from the respondents, found that the DIH's influence goes beyond the four main functions of test and invest; skills and training; support for investment; and ecosystem and networking as identified in the literature (Asplund et al. 2021; Kalpaka et al. 2020; Sassanelli et al. 2021).

This study builds and expands on that concept that makes them relevant to the African context, particularly through its third main theme, demonstrating that DIHs influence integrated ecosystem enhancement. This enhancement occurs via interconnected functions that foster growth and create synergistic effects. This study, therefore, has shown that it is not only about having an important ecosystem, but the activities of that ecosystem make the DIH relevant to entrepreneurs and start-up activities.

Cherunya and Ahlborg (2020) emphasise that the effectiveness of DIHs is highly context-dependent and strategies that succeed in one region may not be applicable or effective in different economic, regulatory or cultural environments. This study found this to be particularly true among DIH or programme managers across various African countries. The challenges faced in Rwanda differed from those encountered in Kenya and South Africa. Digital innovation hubs in developing regions often face significant resource constraints that limit their effectiveness. This study revealed that this is a challenge including inadequate funding and insufficient skilled personnel. Vakirayi and Van Belle (2020) note that the effectiveness of DIHs is often hampered by resource limitations, particularly in developing regions where funding, technology and skilled personnel are scarce.

Another concern is the uneven distribution of benefits provided by DIHs. Not all start-ups benefit equally, those with better initial resources or stronger networks are more likely to leverage DIH support effectively, potentially exacerbating existing inequalities within the entrepreneurial ecosystem. Jiménez and Zheng (2021) point out that DIHs may inadvertently reinforce existing inequalities, as start-ups with more resources and better networks are more likely to benefit from the services provided. This was not found to be a major concern within this study, with resource constraints affecting all start-ups.

The findings of this study highlight the multifaceted roles of DIHs particularly in Africa. Institutional theory suggests that people's desire to become entrepreneurs is shaped by the context in which they live, and DIHs provide both formal support structures and foster informal networks crucial for start-up success (Dheer 2017; DiMaggio & Powell 1983). Main theme three revealed DIHs as an integrated ecosystem enhancement that acts as facilitators that bring together various stakeholders, creating opportunities for collaboration, resource sharing and knowledge exchange.

This integrated ecosystem ensures that start-ups are embedded in a supportive network that includes access to funding, mentorship programmes, and connections with other entrepreneurs and industry professionals (Kalpaka et al. 2020; Sassanelli et al. 2021). By providing such a structured environment, DIHs enable start-ups to thrive through both formal support structures and informal networks (Crupi et al. 2020; Kalpaka et al. 2020). This practical application of institutional theory demonstrates how a supportive ecosystem can shape EA and contribute to the success of start-ups (Audretsch & Belitski 2017; Ferreira et al. 2017).

Cluster theory is validated by the evidence of geographical and resource-based advantages provided by DIHs, which cluster start-ups together, facilitating collaboration and resource sharing (Porter 2003; Spigel & Harrison 2018). This statement aligns with the themes identified in this study. The clustering of start-ups facilitated by DIHs supports their growth by providing a concentrated environment with accessible resources, mentorship and collaboration opportunities (Kalpaka et al. 2020; Sassanelli et al. 2021).

Holistic development support is achieved through comprehensive services ranging from infrastructure to funding, more effectively delivered in a clustered setting (Crupi et al. 2020; Kalpaka et al. 2020). The economic contribution and assessment of start-ups are enhanced within

clusters, fostering competitive yet supportive dynamics that drive growth (Audretsch & Belitski 2017; Ferreira et al. 2017). Additionally, integrated ecosystem enhancement is realised as DIHs connect start-ups with diverse stakeholders, ensuring a seamless flow of knowledge and resources (Porter 2003; Spigel & Harrison 2018). This study contributes to cluster theory by providing empirical evidence on how DIHs create and sustain entrepreneurial clusters, particularly in Africa, highlighting the importance of integrated support systems and dynamic interactions within a DIH.

Conclusion

This study has explored the significant influence of DIHs on the growth of start-ups within the African context. By examining the various functions of DIHs, including their roles in providing critical infrastructure, mentorship, funding support, skills training and ecosystem networking, the study has demonstrated how these hubs serve as vital catalysts for start-up growth. The findings highlight that DIHs not only facilitate the practical and market viability of start-ups but also create a synergistic environment that integrates multiple support functions, thereby enhancing the overall EA and resilience of start-ups.

The research underscores the importance of DIHs in promoting innovation and economic development, particularly in regions with unique socio-economic challenges like Africa. The themes of supporting start-up growth and success, holistic development support and integrated ecosystem enhancement elucidate the multifaceted roles of DIHs in fostering start-up growth. These insights provide valuable implications for policymakers, practitioners and researchers aiming to leverage DIHs to drive economic growth and innovation. By continuing to support and expand the functions of DIHs, stakeholders can ensure that start-ups receive the comprehensive support necessary to thrive in competitive and evolving markets.

This study faced several limitations. Firstly, the sample included DIHs from various African countries which provided rich data, but each DIH is unique in resources and operations, which challenges the generalisability of the findings. Only one DIH/programme manager per hub was interviewed, potentially missing the full spectrum of perspectives within each DIH. Secondly, the study's time sensitivity is notable, as DIHs are a recent concept, and technological advancements may have changed the DIH landscape by the research's completion. Lastly, although the number of participants was acceptable and data saturation was achieved, a larger participant pool might have uncovered additional insights.

During data collection and analysis, several areas for future research were identified. While DIHs were found to influence start-up growth, further research should investigate the sustainability of start-ups within DIH communities compared to those outside. Additionally, as the number of DIHs in Africa increases, expanding the study to include more DIHs could help generalise findings across the continent. Exploring how DIHs support social entrepreneurship and start-ups with social or environmental missions would be valuable, focusing on their unique needs and how DIHs can adapt their services. Future studies should also examine the specific components of digital infrastructure provided by DIHs and their direct impact on start-up performance metrics such as productivity, innovation and market reach. Comparing the effectiveness of DIHs across different regions, considering economic, regulatory and cultural contexts, would identify best practices and contextual factors influencing DIH success. Replicating this study with existing business incubators, technology-based incubators and accelerators could determine how their activities relate to DIH functions. Lastly, investigating the policy and regulatory environments that support DIH establishment and effectiveness could provide insights for policymakers, focusing on regulatory frameworks, incentives and support mechanisms that enhance DIH success and impact on start-up ecosystems.

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Authors' contributions

E.G. contributed to the design and implementation of the research, to the analysis of the results and to the writing of the article. M.M supervised the research study and offered guidance as needed prior to publication.

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Data availability

The data that support the findings of this study are openly available at the University of Pretoria research data management platform at: https://doi.org/10.25403/UPresearchdata.26190611.v1.

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