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Enhancing Productivity: Work-Integrated Learning in the Midlands Space Cluster

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This collaborative effort underscores the power of partnership between academia, industry, and policy in addressing critical issues of productivity and skills development.

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Abstract

This research project, conducted as part of The Productivity Institute's "Investment in Places" initiative, explores the potential link between work-based learning models and productivity, viewed through the lens of place-based investment strategies. Work Integrated Learning (WIL), defined as an educational approach that combines academic studies with practical work experience in a relevant professional setting, is a key focus of this investigation. The research aims to examine how WIL programmes impact productivity by allowing students to apply theoretical knowledge to real-world challenges, potentially bridging the gap between education and industry needs.

The study focuses on WIL programmes in the Midlands' space cluster (this spans the ITL1 regions of the East Midlands and West Midlands) as a case study, examining how closer collaboration between academia and industry through WIL programmes can impact workforce capabilities and sector performance. The research investigates whether WIL approaches in the space sector can contribute to developing a more skilled workforce, fostering innovation, and improving the translation of research into commercial success. By exploring these relationships, the study aims to shed light on how WIL might serve as a mechanism for addressing productivity challenges in high-tech industries, particularly in the context of regional economic development.

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Executive Summary

This report examines the potential of work-integrated learning models to address skills challenges in the UK space sector, with a specific focus on the Midlands Space Cluster. The research was conducted as part of the Productivity Institute's "Investment in Places" initiative, aiming to enhance productivity through place-based investment strategies.

Key Finding: The impact of work-integrated learning on skills development

The four universities in the Midlands space cluster demonstrate a strong commitment to work-integrated learning, each with unique approaches. These range from comprehensive industry projects and internships at Leicester, to intensive industry-relevant skill development at Birmingham, hands-on satellite development at Warwick, and cross-disciplinary integration of space technologies at Nottingham.

Key takeaway
Work-integrated learning significantly enhances students' practical skills and industry readiness, contributing to talent retention in the Midlands space cluster. However, the scale and approach vary among institutions, suggesting the need for tailored strategies based on institutional strengths and local context.

Key Finding: The importance of industry collaboration

Each institution has developed effective models for industry collaboration, ranging from physical hubs like Leicester's Space Park to Birmingham's Industrial Advisory Board, Warwick's long-term industry partnerships, and Nottingham's extensive network of industrial partners, as well as, their Centre for Doctoral Training.

Key takeaway
Strong, diverse industry partnerships are crucial for aligning education with sector needs and providing students with real-world exposure. Institutions should develop flexible collaboration models that can accommodate various levels of industry involvement.

Key Finding: Addressing funding and resource challenges

All institutions face funding challenges, with competition for limited resources impacting programme development and sustainability. This is particularly evident in the need for access to industry-standard equipment and software.

Key takeaway
Diversifying funding sources, including stronger industry partnerships and targeted government support, is crucial for the sustainability and growth of space education programmes. Institutions could also explore resource-sharing models to maximise the impact of available funding.

Key Finding: Balancing theoretical knowledge and practical skills

Whilst all institutions emphasise practical, hands-on experience, they also recognise the need to maintain a strong theoretical foundation. This balance is crucial for producing graduates who are both immediately employable and capable of long-term career growth in the rapidly evolving space sector.

Key takeaway

Educational programmes should strive for a balanced curriculum that combines theoretical knowledge with practical skills, whilst also developing soft skills such as project management, communication, and teamwork. Regular curriculum reviews with industry input can help maintain this balance.

Key Finding: The role of specialised and interdisciplinary approaches

The case studies reveal a mix of specialised programmes (like Birmingham's focus on space weather and materials science) and interdisciplinary approaches (like Nottingham's integration of space technologies across various engineering disciplines).

Key takeaway

Both specialised and interdisciplinary approaches have merit in space education. Institutions should leverage their unique strengths and consider local industry needs when developing programmes, potentially combining both approaches to create well-rounded graduates capable of addressing the diverse challenges in the space sector now and in the future.

Introduction

The United Kingdom's productivity challenge has become increasingly urgent in recent decades, with the nation's productivity gap widening in comparison to leading economies such as Germany and the United States (Coyle et al., 2023). This stagnation in productivity growth has far-reaching implications, limiting income growth, constraining tax revenues, and reducing the economy's resilience to shocks. As the UK grapples with this productivity crisis, attention must turn to innovative solutions across various sectors.

Within this context, the UK has faced significant challenges in its skills policies, characterised by underinvestment and coordination gaps. These issues directly contribute to persistent skills shortages, which in turn severely hamper productivity growth. As highlighted by Grimshaw, O'Mahony, and Westwood (2023), there is a critical and intricate relationship between workforce skills and productivity: when the supply of skilled workers fails to meet industry demand, innovation stagnates, and efficiency suffers. The space industry, a high-tech, high-value sector with significant growth potential, offers a unique lens through which to examine this skills-productivity nexus. In this sector, the presence or absence of specialised skills can dramatically impact technological advancements, operational efficiency, and overall economic output, making it an ideal case study for productivity enhancement strategies rooted in skills development.

This research project, conducted as part of the Productivity Institute's "Investment in Places" initiative, explores the potential link between work-based learning models and productivity, viewed through the lens of place-based investment strategies. Work Integrated Learning (WIL), defined as an educational approach that combines academic studies with practical work experience in a relevant professional setting, is a key focus of this investigation. The research aims to examine how WIL programmes impact productivity by allowing students to apply theoretical knowledge to real-world challenges, potentially bridging the gap between education and industry needs.

The study focuses on WIL programmes in the Midlands' space cluster (this spans the ITL1 regions of the East Midlands and West Midlands) as a case study, examining how closer collaboration between academia and industry through WIL programmes can impact workforce capabilities and sector performance. The research investigates whether WIL approaches in the space sector can contribute to developing a more skilled workforce, fostering innovation, and improving the translation of research into commercial success. By exploring these relationships, the study aims to shed light on how WIL might serve as a mechanism for addressing productivity challenges in high-tech industries, particularly in the context of regional economic development.

The research examines various approaches to WIL, including internships and industry-based projects, implemented through partnerships between Higher Education (HE) institutions and industry. The goal is to identify best practices for accelerating talent development and equipping graduates with the skills necessary to enhance the productivity and competitiveness of the space sector and related industries.

The aims of this project are to:

1. Evaluate the impact of work-integrated learning on skills development, talent retention, and productivity in the Midlands space cluster.
2. Identify effective models and best practices for HE-industry collaboration in the context of the space sector.
3. Develop actionable recommendations and practical tools to inform policies, educational programmes, and employer engagement strategies.

This study explores how WIL initiatives in the space sector can contribute to the broader agenda of enhancing UK productivity, offering insights into a targeted strategy that aligns educational outcomes with the evolving needs of a high-productivity, future-oriented industry. The findings provide valuable guidance for policymakers, educators, and industry leaders seeking to address skills gaps, boost productivity, and foster regional economic growth through targeted investments in human capital development.

Methodology

This research employed a qualitative approach centred on in-depth interviews conducted with representatives from four key university institutions within the Midlands space cluster. The institutions included the University of Birmingham, the University of Warwick, the University of Nottingham (specifically the Nottingham Geospatial Institute), and the University of Leicester. These universities were selected for their significant contributions to space-related education and research in the region. There are other Midlands' universities that contribute to space-related education and research in the region but are not covered by the case studies, including Coventry University, Worcester University and Aston University. Semi-structured interviews were conducted with senior academics and programme leaders from each institution, allowing for a comprehensive exploration of their space education programmes, industry collaborations, and work-integrated learning approaches. The interviews focused on gathering detailed information about curriculum design, student experiences, industry partnerships, and perceived impacts on skills development and regional talent retention.

In addition to the university-focused interviews, this study also included a case study analysis of a national work-integrated learning initiative: the Space Placements in INdustry (SPIN) programme. Funded by the UK Space Agency and managed by the Satellite Applications Catapult, SPIN offers short-term project placements to students, across a wide range of companies in the space sector. This case study involved attendance at a SPIN programme showcase event, where six former SPIN students and their host companies reflected on their experiences. This provided first-hand insights into the programme's impact from both student and industry perspectives. The researcher also reviewed programme documentation to understand SPIN's structure, objectives, and outcomes. The inclusion of SPIN provided a valuable national context for work-integrated learning practices in the space sector, allowing for comparisons with university-specific approaches.

This multi-faceted method enabled the collection of rich, context-specific data that provided deep insights into the unique approaches and challenges faced by each

institution, as well as broader trends in work-integrated learning within the UK space sector. The data collected from these interviews and the SPIN case study formed the basis for the case studies presented in this research, offering a nuanced understanding of space education practices in the Midlands space cluster and their relationship to national initiatives.

The Midlands Space Cluster

The United Kingdom's space sector is experiencing a significant resurgence, characterised by rapid growth and innovation. According to recent industry data, the UK space industry's total income grew by 5.1% in real terms to £17.5 billion in 2020/21, outpacing both the global space industry (+1.6%) and the wider UK economy, which declined by 7.6% during the same period (Gov.UK, 2022). This growth is particularly noteworthy in the context of economic challenges, with the space industry demonstrating resilience and potential. The sector now comprises 1,590 organisations, with 29 new incorporations in the past year, indicating a dynamic and expanding industry landscape. The importance of space and space applications has become increasingly evident, with a marked trend towards greater dependence on space-based capabilities by governments, the public, and commercial users. This growing reliance underscores the critical role of space technologies in various sectors, including communication, navigation, Earth observation, and national security. The proliferation of satellite-enabled applications has not only revolutionised daily life but also highlighted the need for a robust and resilient space industry to mitigate potential security, societal, and economic risks associated with disruptions to these vital services. Central to this growth and resilience is the development of regional space clusters, recognised as vital components for fostering a robust national ecosystem and driving continued growth in the space sector. This research focuses on the Midlands Space Cluster, examining its role in nurturing skills, retaining talent, and boosting productivity through work-integrated learning (WIL) initiatives. The importance of such initiatives is underscored by the industry's highly skilled workforce, with over 77% of employees holding at least a primary degree, higher than any other sector in the UK.

The Space Cluster Development Programme, funding 15 regional space clusters across the UK, plays a crucial role in steering this growth. These clusters provide local support programmes and platforms for knowledge sharing, creating collaborative opportunities and event access. They also offer centralised guidance for space companies exploring new sectors. This approach aims to diversify the space industry's portfolio, encouraging collaboration between sectors and government entities, and fostering substantial growth prospects. Within this context, this study aims to identify effective models and best practices for Higher Education-industry collaboration specific to the space sector.

The Midlands Space Cluster has emerged as a key player within this national framework. Supported by a £6.5 million funding allocation from the UK Space Agency, this initiative involves collaboration among key stakeholders from the University of Leicester, Midlands Aerospace Alliance (lead partner), University of Birmingham, University of Nottingham, and the Manufacturing Technology Centre (MTC). This research evaluates

the impact of WIL initiatives within this cluster on skills development, talent retention, and productivity.

The cluster benefits from the region's strong educational and research infrastructure. Leading institutions like the University of Leicester, the University of Birmingham, and the University of Nottingham contribute significantly to space research and education. In addition, world-class facilities such as Space Park Leicester, the National Space Centre, and the Manufacturing Technology Centre support cutting-edge research and development. The region offers a comprehensive range of space-related educational opportunities, from A-Level to Postgraduate studies, supported by organisations like the National Space Academy. This study examines these educational programmes and their integration with industry needs. The cluster's strength is reinforced by a robust industry presence, with major companies with strong space sector involvement having significant operations in the region. These companies include GMV, Honeywell Hymatic, and Rolls-Royce. Additionally, the Midlands hosts a large population of Small and Medium Enterprises (SMEs) which are suppliers into the space and related sectors, contributing to a diverse and dynamic industry landscape. This research explores to what extent these industry players engage with educational institutions in the region and contribute to WIL initiatives.

By examining the unique characteristics and initiatives of the Midlands Space Cluster, this study aims to develop actionable recommendations and practical tools to inform policies, educational programmes, and employer engagement strategies. The Midlands Space Cluster is notable for its concentration of aerospace and advanced manufacturing expertise, as well as its strong links between academia and industry. It encompasses key institutions such as the University of Leicester's Space Park and the National Space Centre, fostering innovation and collaboration in space-related research and development. These insights, drawn from the Midlands' distinctive ecosystem, will contribute to enhancing the effectiveness of WIL in the space sector, ultimately supporting the growth and competitiveness of the UK space industry as a whole.

Work-Integrated Learning (WIL)

Work-integrated learning (WIL) has emerged as a crucial strategy for addressing skills gaps and enhancing productivity in various sectors, including the space industry. This summary synthesises key findings from recent research and reports on WIL and related concepts.

Context and Importance

Skills development initiatives are crucial for addressing skills and productivity gaps in the UK workforce, enhancing capabilities, boosting efficiency, and driving economic growth (Grimshaw, O'Mahony, and Westwood, 2023; Edwards, 2024). However, traditional approaches are seen as inadequate, given issues like underinvestment and poor coordination in the UK's skills policies (Clayton and Evans, 2021). This is evidenced by declining employer investment in skills, with the cost per employee in the UK being half

the EU average and the number of days spent training at its lowest since 2011 (Clayton and Evans, 2021; Green and Taylor, 2020). Recent research has identified nine strategic areas essential for strengthening the UK's workforce, including Apprenticeship expansion (including to doctoral level); Career guidance; Digital literacy programmes; Diversity and inclusion initiatives; Flexible learning models; Importance of "soft skills"; Industry collaboration; Lifelong learning culture; and Recognition of prior learning (Edwards, 2024).

The importance of lifelong learning, as one of the nine strategic areas, cannot be overstated. The literature shows that engaging in continuous learning and training in mid and later life improves employment opportunities, strengthens economies, and improves general wellbeing (International Longevity Centre UK, 2024). In response to this, Higher Technical Qualifications (HTQs) have been introduced as employer-led technical qualifications at Level 4 and Level 5, providing an alternative to apprenticeships or degrees (Anwar and Ramaish, 2024). HTQs are designed to provide the skills employers require while also being designed for modular and flexible study, allowing learners to engage in courses while remaining at work (Anwar and Ramaish, 2024). However, the uptake and utilisation of HTQs remain low due to a lack of awareness, financial disincentives, lack of flexibility, and uncertainty about employment prospects (Anwar and Ramaish, 2024).

Despite the introduction of alternative qualifications, the continued importance of university graduates, especially in high-tech sectors, remains paramount. Universities continue to play a crucial role in preparing students for the rapidly evolving job market by integrating several key initiatives. At the centre of this is the promotion of digital literacy, which equips graduates with the technological skills required across all industries. These programmes are increasingly designed with diversity and inclusion in mind, ensuring that students from all backgrounds have equal access to digital skills development. This inclusive approach is further supported by flexible learning models, which allow students to adapt their education to their personal circumstances and career goals, much like the modular structure of HTQs. These flexible models not only accommodate diverse learning needs but also facilitate the development of essential "soft skills" such as time management and self-motivation. The emphasis on soft skills extends beyond adaptability to include communication, critical thinking, and teamwork – competencies that are honed through innovative teaching methods and, crucially, through industry collaboration. These partnerships with businesses facilitate internships, and joint research projects, providing students with real-world experience that bridges the gap between academic learning and industry needs. This collaborative approach exemplifies ‘work-integrated learning’ (WIL) and helps align the curriculum with current industry demands, ensuring that graduates are well-rounded, adaptable, and prepared for the challenges of the modern workforce. Through this interconnected strategy, universities produce graduates who are not only technically proficient but also possess the diverse skill set required to thrive in high-tech fields and drive innovation in an increasingly complex global economy.

Benefits of Work-Integrated Learning

The benefits of WIL are multifaceted, addressing skills development, talent attraction and retention, and fostering a culture of continuous learning. One of the primary advantages of WIL is alignment with defined tasks or roles and skill set requirements needed by the industry (Ferguson, 2022). This supports the development of transferable skills and helps to offer clear pathways for future career progression (Evans, 2023; Young and Rooney, 2023). Collaboration between educational institutions and industry is crucial for providing students with valuable work experience, enhancing their future employability and understanding of the professional world (O Regan and Bhattacharya, 2023). Madgavkar (2022) argues that work experience accounts for about half of the average person's accumulated human capital, reinforcing that WIL can be a powerful tool for skills development. This 'experience effect' can have long-lasting benefits for participants, as individuals gain a significant advantage from early experience in effective organisations. This aligns with the finding that "experience seekers" and "early movers" successfully harness the dynamic of learning through work, with experience accounting for 60 to 70 percent of their lifetime earnings in advanced economies (Madgavkar, 2022).

Implementation and Best Practices

Successful work-integrated learning (WIL) programmes are enabled by collaboration between universities and industry partners. Industry partners play a crucial role in providing authentic contexts for students to develop and apply both technical skills and critical transferable skills (such as communication, teamwork, and problem-solving) (Hansberry and Gerhardt, 2023). Furthermore, to ensure educational provision matches local needs, deep consultation with a broad range of employers is vital, which leads to better outcomes for learners and helps to address key skills gaps (Walker, 2021). However, despite businesses acknowledging their responsibility to invest in the skills of their workforce, too few firms are doing so proactively (British Chambers of Commerce, 2021).

Generating and coordinating stronger partnerships between universities and industry partners requires resources and time. University Business Engagement Teams and other Partnership Managers play vital roles in engaging with industry and coordinating work experience programmes (O Regan and Bhattacharya, 2023). A long-term, comprehensive strategy is needed to provide stability to these roles and pathways for stakeholder collaboration (Robson, 2023). Therefore, government support is essential for creating the necessary infrastructure to facilitate broad engagement with various businesses, including SMEs and microbusinesses, to ensure representation (O Regan and Bhattacharya, 2023; Walker, 2021). Additionally, incentivising private sector skills investment through the public procurement process could encourage greater employer participation (British Chambers of Commerce, 2021).

Challenges and Considerations

Despite the numerous benefits of Work-Integrated Learning (WIL) some significant challenges and barriers hinder widespread implementation and participation in such programmes. Recent studies have highlighted the multifaceted nature of obstacles related to adult learning, which could be applied to this context. Hall (2022) found that 65% of current or recent learners have encountered at least one challenge while learning, with work and time pressures being the most common, cited by 24% of respondents. For those who have not engaged in learning in the last three years, 70% identified at least one barrier preventing them from doing so (Hall, 2022). These barriers can be categorised as dispositional, situational, and institutional (Parliamentary Office of Science and Technology, 2021). Dispositional barriers, related to attitudes and expectations, were cited by 52% of respondents who had not recently participated in learning (Parliamentary Office of Science and Technology, 2021). Situational barriers, arising from individual circumstances, were mentioned by 40% of respondents, with costs (25%) and time pressures (18%) being the most significant factors (Parliamentary Office of Science and Technology, 2021). Institutional barriers, including staff shortages in further education and restrictive eligibility criteria for funding, also play a crucial role in limiting access to adult education (Parliamentary Office of Science and Technology, 2021). Understanding and addressing these challenges is crucial for the successful implementation and expansion of WIL programmes.

Future Directions

There is a growing recognition that traditional education models may no longer be sufficient to meet the demands of an ever-evolving job market. WIL is becoming increasingly important to ensure that learners are equipped with the most relevant and up-to-date skills required in the modern workplace (Scottish Government, 2023; Kelly, 2020). Policy recommendations include increased funding for WIL initiatives, addressing both supply and demand for skills, and creating more flexible learning pathways (Parliamentary Office of Science and Technology, 2021). These recommendations aim to make WIL programmes more accessible, effective, and aligned with industry needs. The potential of work-integrated learning to address skills shortages and gaps is particularly significant in sectors like the space industry that require specialised and rapidly evolving skill sets. In this context, 'gaps' refer to deficiencies in the current workforce within organizations (the internal labour market), where existing employees may lack certain skills or competencies needed for their roles. 'Shortages', on the other hand, relate to difficulties in finding suitably skilled candidates in the external labour market to fill vacant positions. Both gaps and shortages can hinder industry growth and innovation, making WIL programs crucial in bridging these divides. As these industries continue to grow and change, WIL programs will play a crucial role in ensuring a skilled and adaptable workforce, capable of meeting both current and future challenges in terms of internal skill development and external talent acquisition.

The Role of WIL in Addressing Space Sector Challenges

The UK space sector, despite its recent growth, faces significant constraints that hinder its ability to innovate, scale-up, and deliver solutions effectively. This directly impacts firm productivity and at the heart of these constraints lies a critical challenge: access to the diverse skillsets required to drive the industry forward. Recognising this, both government and industry have prioritised addressing skills needs and recruitment challenges as key to unlocking the sector's growth potential (UK Space Agency, 2023).

Current skills shortages in the UK space sector are multifaceted, since the industry operates in a landscape of extreme and unique risks (Billing et al., 2024; Billing and Bryson, 2019). Beyond the common challenges faced by all industries—such as technological change, new competitors, and shifting demand—the space sector grapples with additional, idiosyncratic risks. These include critical concerns around launch and citizen safety, the high costs associated with space infrastructure, the near impossibility of repairing satellites once in orbit, and the harsh environmental challenges of space, including extreme vibration, temperature fluctuations, and pressure differentials. It is imperative, therefore, that the workforce not only possesses technical skills but also 'soft skills' which include an appreciation of these unique risks. In terms of the technical skills, there is a notable scarcity of professionals in software development, systems engineering, and radio-frequency specialisation (UK Space Agency, 2023). The situation is further exacerbated by the high cost and limited availability of relevant courses, acting as significant barriers to continuous workforce training and development.

Retention of skilled professionals within the space sector presents another challenge. To effectively retain skills, there is a pressing need to increase the overall size of the workforce. This necessitates a multifaceted approach to attract not only students and new workforce entrants but also mid-career professionals from adjacent industries. Traditional education approaches have proven inadequate in addressing these complex challenges. In response, there is growing recognition of the potential of work-integrated learning models as a more effective solution, which provide students and professionals with real-world experience that is directly applicable to the unique demands of the space sector. These models help learners develop not only technical skills but also critical transferable skills and the commercial acumen that are currently in short supply. The success of these initiatives could create a more resilient, adaptable, and skilled workforce capable of navigating the unique risks and challenges of the space industry while driving innovation and growth.

Skills Landscape in the Midlands Space Industry

The space sector in the Midlands, like the broader UK space industry, faces significant challenges in workforce development and skills availability. These challenges, highlighted in the Space Sector Skills Survey 2023, provide crucial context for evaluating the impact of work-integrated learning and identifying effective models for industry-academia collaboration.

The survey reveals that 52% of organisations in the sector reported skills gaps in their current workforce, with software and data skills being the most critical shortage. Commercial operations and transferable skills were also identified as significant areas of need. These skills gaps had a moderate to major impact on 71% of organisations, affecting workloads, business opportunities, and quality standards. Recruitment challenges were also evident, with two-thirds of companies in the Midlands having recruited in the previous year. While the difficulty in recruiting was lower than the national average, it remained significant. This highlights the importance of developing a robust pipeline of skilled graduates who are well-prepared for the industry's needs. The survey also revealed that 72% of organisations provided training, with on-the-job training being the most common form. However, lack of time, expense, and availability were cited as major barriers to training. This finding emphasises the value of educational programs that incorporate practical, industry-relevant experiences, reducing the burden on companies to provide extensive on-the-job training for new hires. Retention of the workforce was identified as an increasingly challenging issue, especially for small companies. However, the survey noted that once in the space sector, professionals tend to stay within it, although they often move between companies. This trend highlights the importance of creating strong industry-academia connections early in students' careers.

These survey findings provide valuable context for developing targeted strategies to enhance productivity through improved education-industry collaboration. They underscore the importance of work-integrated learning approaches in addressing the skills gaps and challenges faced by the Midlands space industry.

Introduction to Case Studies

The five case studies presented in the next section showcase a range of innovative space education and industry collaboration initiatives, particularly in the Midlands region. The SPIN Programme, funded by the UK Space Agency and supported by the Satellite Applications Catapult, is an example of a comprehensive, cross-cutting internship programme that bridges academia and industry on a national scale. The MSc Space Engineering Programme at the University of Birmingham demonstrates a focused postgraduate initiative designed to address specific industry needs. The Warwick University Satellite Team (WUSAT) programme illustrates a long-running, hands-on undergraduate project that closely simulates real-world space industry practices. The Nottingham Geospatial Institute (NGI) at the University of Nottingham exemplifies a cross-disciplinary approach to integrating space technologies into broader engineering education. Finally, the University of Leicester's space education programmes showcase a comprehensive ecosystem of space-related courses and initiatives, including the innovative Space Park Leicester, which fosters direct industry collaboration on a significant scale.

Case Study 1: SPIN Programme

The space sector in the United Kingdom benefits from a comprehensive, cross-cutting internship programme that complements individual courses and activities at university institutions within particular clusters. This initiative, known as the Space Placements in INdustry (SPIN) programme aims to bridge the gap between academia and industry, helping students translate their studies into practical experience while supporting the growth and innovation of the UK space sector. It provides mutual benefits, offering students valuable industry exposure and companies access to fresh talent and ideas, encompassing both the technical and business sides of the space industry.

Funded by the UK Space Agency and managed with support from the Satellite Applications Catapult, the SPIN programme offers short-term projects, typically lasting 8 weeks. The scheme was started in 2013 and has experienced significant growth in recent years, expanding from 40 placements to 135 placements at 73 companies. SPIN is open to registered students from any discipline and any year of undergraduate or postgraduate studies, including those pursuing business degrees as well as those involved in technical engineering fields. This inclusive approach ensures a diverse pool of talent and experience levels and is somewhat broader than the other examples from the Midlands WIL programmes.

For the interns, known as SPINterns, the benefits are substantial. They receive paid work placement experience to enhance their CVs and have the opportunity to apply their academic knowledge to real-world projects. This applies to both business-oriented roles and technical engineering positions, providing a diverse range of experiences within the space sector. The programme includes a unique induction event that provides perspective on the UK space sector, as well as a showcase event where interns can promote their newly acquired skills to potential employers. SPINterns gain first-hand experience of the skills that employers value, with the potential for extended employment or permanent positions. The programme also offers valuable networking opportunities within the space industry.

Host companies also reap significant benefits from participating in the SPIN programme. They gain access to bright, enthusiastic students who bring fresh ideas and up-to-date academic knowledge to their teams, whether in business development or technical roles. This provides additional resources for specific projects or work that may lack internal capacity. The programme also offers an opportunity to informally assess potential future employees, potentially saving on recruitment costs. For SMEs in particular, hosting a SPINtern can provide a notable increase in workforce capacity. There are also examples of where SPINterns have created marketable products or delivered training to clients, providing tangible value to their host organisations.

Case Study 2: Birmingham MSc Space Engineering Programme

The MSc Space Engineering programme at the University of Birmingham, launched in 2023, is a 12-month, full-time course designed to provide advanced education in space-related engineering. The programme combines core aerospace engineering principles with specialised space-related modules, offering a unique blend of theoretical knowledge and practical skills. The curriculum includes modules such as Space Mission Analysis and Design, Space Environment, Materials and Manufacturing for Space Applications, Communications and Ethics in Space Missions, Satellite Communications, and Cubesat Design. The intake doubled from the first to the second year of the programme and application numbers continue to rise. The programme aims to prepare graduates for careers in the evolving space industry by addressing specific skills needs, particularly in radio frequency engineering and materials.

In its inaugural year, the programme admitted a small cohort of students from diverse backgrounds, allowing for personalised attention and intensive learning experiences. Most of these students were recent graduates from engineering or physical science disciplines, while one was a professional with prior work experience in IT services who was seeking to transition into the space sector. The small cohort size facilitated close collaboration with faculty and industry partners.

Impact of work-integrated learning on skills development, talent retention, and productivity

The UoB MSc Space Engineering programme demonstrates a strong potential for a positive impact on the Midlands Space Cluster, though its influence is still emerging due to the programme's recent launch. Unique features such as the compulsory Space Environment module, taught by space weather specialists, provides unique expertise not commonly found in other programmes; whilst the ‘Materials and Manufacturing for Space Applications’ module responds to industry feedback about the difficulty in recruiting materials engineers for the space sector.

A key feature of the programme is its strong alignment with industry needs. This is achieved through an Industrial Advisory Board guiding curriculum development, industry-supported projects and external mentorship. Practical experience is also gained through hands-on projects, including environmental testing at facilities like RAL Space. This exposure to real-world procedures enhances students' technical skills and understanding of industry practices. The programme also emphasises soft skills development, particularly through the ‘Communications, Ethics and Teamwork for Space Missions’ module and group projects that require team presentations to diverse audiences. This holistic approach to skills development prepares graduates for the collaborative and complex nature of the space industry.

Early indicators suggest positive outcomes for talent retention, with graduates securing positions in the space sector. Notably, one graduate obtained a position as a space

materials engineer at the Manufacturing Technology Centre (MTC) in the Midlands, directly contributing to the local space ecosystem. This demonstrates the programme's potential to feed skilled professionals into the regional space industry. To enhance local talent retention, existing programme connections with national organisations should be supplemented by strengthening ties with regional space companies and initiatives. This effort should not fall solely on the University of Birmingham, but rather be viewed as a collective responsibility of the entire Midlands Space Cluster and its stakeholders. By fostering collaboration between academic institutions, industry bodies like the Midlands Aerospace Alliance, research centres such as MTC, and local space companies, the region can develop a more cohesive and effective approach to talent development and retention, ultimately enhancing the competitiveness of the Midlands space ecosystem.

The programme's specialisation allows graduates to compete for space sector jobs immediately, potentially reducing brain drain to other regions or industries. As the cohort size grows, the potential for significant regional impact increases. While it is too early to quantify the programme's impact on regional productivity, its focus on industry-relevant skills, particularly in materials, has the potential to enhance regional capabilities. The small cohort size allows for tailored learning experiences, potentially producing highly skilled graduates who can make immediate contributions to employers. As more graduates enter the workforce and the programme expands, a clearer picture of its impact on regional productivity should emerge.

Effective Models and Best Practices for HE-Industry Collaboration

The MSc Space Engineering programme employs several effective models for industry collaboration, which could serve as best practices for similar programmes. One key element is the Industrial Advisory Board. This board ensures ongoing alignment between the curriculum and industry needs, allowing for regular feedback and updates to keep the programme relevant in a rapidly evolving sector. This model effectively bridges the gap between academic learning and industry requirements, producing graduates who are better prepared for the workforce.

Another effective practice is the use of industry-supported projects. While projects are not directly based in industry, they are supported by companies like In-Space Missions, providing students with real-world context and guidance. This model strikes a balance between academic freedom and industry relevance, allowing students to develop practical skills while maintaining educational objectives. The programme offers both modelling and design-and-build projects, enabling students to align their skills development with specific industry needs and personal career goals. This flexibility can make graduates more adaptable to various roles within the space sector. The programme also maintains a strong alumni network, with connections maintained with graduates via LinkedIn and the University's Development and Alumni Relations Office (DARO). Graduates are invited to speak to current cohorts to share their experiences and raise awareness of opportunities. This creates a valuable feedback mechanism, providing current students with insights into industry trends and potential career paths while allowing the programme to stay updated on the evolving needs of the sector.

Hands-on experience and industry interaction are also key components of the programme's success. Students gain practical experience through core and optional modules, and through project activities that expose them to industry-standard facilities and practices. This hands-on approach, combined with opportunities to interact with industry professionals, significantly enhances the work-readiness of graduates. These models of industry collaboration not only improve the educational experience but also strengthen the ties between academia and the space sector, ultimately contributing to a more skilled and industry-aligned workforce.

Actionable recommendations and practical tools

Based on the insights from the MSc Space Engineering programme, several recommendations and practical tools have been identified to enhance the effectiveness of similar initiatives across educational institutions, industry, and policymakers.

For educational institutions, it is recommended to offer more specialised, industry-informed modules to address specific skills gaps identified by the space sector, like the UoB example. This could include advanced courses in radio frequency engineering, space materials, or emerging areas like space debris management. Institutions could also increase opportunities for hands-on experience by establishing partnerships with a wider range of regional and national space companies.

In terms of industry engagement, companies are encouraged to participate more actively in curriculum development through roles on Industrial Advisory Boards, supported projects, guest lectures or even co-designed modules. This deeper involvement can ensure that graduates possess the most current and relevant skills However, activities such as co-designing modules would require a substantial investment of a company's time, which is unlikely to be feasible. Additionally, collaboration with educational institutions to create industry-standard testing and development environments on campus would allow for more integrated practical learning.

Policymakers can play a crucial role by developing targeted funding initiatives for space education programmes that demonstrate strong industry collaboration and regional impact. This could include grants for equipment, industry secondments for academics, or support for student projects. Supporting the development of a more cohesive Midlands Space Cluster would enhance collaboration opportunities between academia, industry, and research institutions. By implementing these recommendations and tools, stakeholders can enhance the effectiveness of space engineering education programs, strengthen industry-academia collaborations, and ultimately contribute to the growth and competitiveness of the Midlands space cluster.

Case Study 3: WUSAT Programme

The Warwick University Satellite Team (WUSAT) programme is a pioneering initiative in space engineering education that has been running since 2006. This innovative programme stands out as a comprehensive, industry-aligned learning experience that bridges the gap between academic theory and real-world space engineering practices. WUSAT is a module in the 4th year of engineering studies, comprising 25% of the year's work. It typically involves 8-9 students per year, with additional involvement from PhD students. The programme focuses on the development of cube satellites, providing students with hands-on experience in satellite design, construction, and potential launch.

The programme operates on a multi-year timeline, with each cohort of students building upon the work of previous teams. Students work through various phases of satellite development, including requirements analysis, design, prototyping, and testing. They follow a methodology adapted from European Space Agency (ESA) practices, tailored to fit within academic constraints. WUSAT maintains collaborations with industry partners, including regular interactions with companies like Airbus and SSTL. The programme has participated in ESA's student satellite initiatives and has developed satellites to carry payloads for various research project. The project takes a multidisciplinary approach, combining students from different engineering streams such as mechanical, electrical, electronic, and computing. This structure allows for the formation of teams that mirror the diverse skill sets required in the space industry.

WUSAT operates with limited funding and relies heavily on industry partnerships and the dedication of its leadership. The programme faces challenges in terms of continuity between academic years and integration with traditional university research structures.

Impact of Work-Integrated Learning on Skills Development, Talent Retention, and Productivity

The WUSAT programme demonstrates significant positive impacts on skills development, talent retention, and productivity within the Midlands space cluster. As an integrated part of the curriculum. This integration ensures that students receive academic credit for their participation, underlining the programme's importance in their overall education.

The programme offers students a comprehensive, hands-on experience in satellite development, specifically focusing on cube satellites. This experience covers the entire lifecycle from requirements analysis to design, prototyping, testing, and potential launch, providing a depth of learning that is rare in traditional academic settings. Through this end-to-end approach, students gain a holistic understanding of satellite development, preparing them for the complexities of real-world space projects.

Through collaborations with industry partners like Airbus, SSTL, and the European Space Agency (ESA), students are exposed to real-world engineering practices and review

processes, further enhancing their practical skills. These strong links with major space industry players provide students with invaluable real-world exposure and networking opportunities. The programme fosters crucial abilities in concurrent engineering, systems engineering, knowledge transfer, and project handover - all vital competencies in the space industry.

One of the unique aspects of WUSAT is the practical experience students gain working with technicians. This interaction teaches them about the realities of manufacturing and design constraints, bridging the gap between theoretical knowledge and practical application. Additionally, the project structure enhances students' time management skills and their ability to balance multiple priorities, closely mirroring real-world work environments.

The programme's impact on talent retention is evident in the career trajectories of its alumni. Over its 18-year history, WUSAT has built a substantial alumni network, with many former students now working in prominent positions in the space industry, including roles at Airbus, SSTL, and ESA. This indicates strong talent retention within the sector. The alumni network serves as a valuable resource for current students and the industry alike, facilitating knowledge transfer and career opportunities.

In terms of productivity, the WUSAT programme addresses a critical gap in the UK space sector between upstream (technology development) and downstream (data usage) activities. By focusing on the crucial middle ground of satellite design and launch preparation, the programme potentially enhances overall sector productivity. Furthermore, the programme provides a low-cost, custom-made satellite development service for research payloads, contributing to research and development in the space sector. WUSAT also plays a significant role in promoting diversity and inclusion in the space sector. The programme has a strong track record of involving women in space engineering projects and collaborates with initiatives to encourage broader participation in STEM fields. This commitment to diversity not only enriches the learning experience but also contributes to building a more inclusive future workforce for the space industry.

Effective Models and Best Practices for HE-Industry Collaboration

The WUSAT programme exemplifies several effective models and best practices for collaboration between higher education and industry in the space sector. The programme's integration into the curriculum as a substantial module is a key best practice. This integration gives WUSAT academic credibility and ensures consistent student engagement, while also demonstrating to industry partners the university's commitment to practical, industry-aligned education.

WUSAT's long-term project structure is particularly noteworthy, with students building upon the work of previous teams. This approach simulates the long-term nature of real space missions and allows for complex, realistic projects that mirror actual space industry timelines. It also teaches valuable skills in project continuity and knowledge

transfer - skills that are crucial in the space industry where projects often span many years.

The programme's industry partnerships are a cornerstone of its success. Regular collaborations with companies like Airbus, SSTL, and ESA provide students with real-world exposure and keep the project aligned with industry needs. Annual training days with Airbus, sometimes including other universities, enhance knowledge sharing and provide valuable networking opportunities.

WUSAT's adaptation of industry methodologies for an academic setting is another best practice. By adapting space industry methodologies to fit within academic constraints, the programme provides a comprehensive, authentic experience that closely mirrors industry practices while still meeting educational requirements. This approach ensures that students are well-prepared for the realities of working in the space sector upon graduation. Lastly, the programme's reliance on networking-based collaborations for initiating project payloads and missions demonstrates the importance of relationship-building in the space sector. This approach not only sources interesting projects for students but also reinforces the programme's connections with the wider space community.

Actionable recommendations and practical tools

Based on the insights from the WUSAT programme, several recommendations and practical tools have been identified to enhance the effectiveness of similar initiatives across educational institutions, industry, and policymakers.

Educational institutions should consider expanding the multidisciplinary approach of their programme, like the WUSAT example. This could involve broadening participation to include students from additional relevant disciplines such as physics, computer science, and even business or project management. Such an expansion would further enhance the real-world simulation of space industry teams. Implementing a formal knowledge transfer system is crucial for programme continuity. Institutions should develop a structured system for knowledge transfer between cohorts, potentially including detailed handover documents, mentoring sessions between outgoing and incoming students, and a comprehensive project wiki.

To better prepare students for industry practices, institutions should enhance industry-standard software training. This involves incorporating more industry-standard software tools and practices into the curriculum, such as advanced CAD/CAM software, systems engineering tools, and project management software used in the space industry. Creating a virtual mission control centre on campus would provide a more immersive experience for students. This dedicated space would simulate a mission control environment, providing students with a collaborative work area that mirrors real-world operational settings.

Developing industry-sponsored challenges would provide students with real-world problem-solving opportunities. Working with industry partners, institutions could create annual design challenges or competitions that address real industry problems, with the potential for winning designs to be further developed or implemented. Implementing an industry mentorship programme would provide valuable guidance to students. Each student or student team could be paired with an industry mentor who can provide guidance, industry insights, and career advice throughout the project. Creating an industry advisory board would ensure ongoing alignment with sector needs. Institutions should establish a formal advisory board with representatives from various space companies to guide curriculum development, ensure industry relevance, and facilitate stronger academia-industry links.

Developing a Space Education Innovation Fund could provide crucial support for innovative programmes. Policymakers should create a dedicated fund to support innovative space engineering education programmes, with a focus on those that demonstrate strong industry collaboration and potential for regional economic impact. This initiative could be implemented at multiple scales for maximum effectiveness. At the national level, the UK Space Agency, in collaboration with the Department for Education and UK Research and Innovation, could establish an overarching framework and provide core funding. This national approach would ensure consistency and strategic alignment with broader UK space sector goals. At the pan-regional Midlands scale, organisations like the Midlands Engine or the Midlands Aerospace Alliance could manage a specific allocation of the fund, tailoring it to the unique strengths and needs of the Midlands space cluster. Additionally, at a more local scale, combined authorities could contribute additional resources and help direct funding to address specific local skills gaps and economic priorities. This multi-tiered approach would allow for both strategic national coordination and the flexibility to address regional and local needs, maximising the fund's impact on space education and industry growth.

Creating incentives for industry-academia collaboration could boost engagement. Policymakers should develop match fund programmes for companies that actively engage with and support space engineering education programmes. This initiative could be structured as a tiered system, with different levels of matching based on the extent of company involvement. For instance, a basic level might offer a 1:1 match for companies providing internships or sponsoring student projects. A higher tier could offer a 2:1 match for more substantial commitments, such as co-developing curricula or providing long-term research partnerships. The programme could be administered by the UK Space Agency in collaboration with regional bodies like the Midlands Space Cluster. To ensure broad participation, the match funding could be capped at a certain amount per company, allowing both SMEs and large corporations to benefit. The programme could also include a streamlined application process, with regular submission windows throughout the year to accommodate different academic and industry cycles. To measure impact, participating companies and academic institutions could be required to report on outcomes such as student placements, joint research outputs, and eventual graduate employment. This data would not only justify the programme's continuation but also provide valuable insights into the evolving needs of the space sector workforce.

By implementing these recommendations based on the WUSAT programme, stakeholders can enhance similar space engineering education initiatives. This will strengthen industry-academia collaborations, improve the practical skills of graduates, and ultimately contribute to the growth and competitiveness of the Midlands space cluster and the broader UK space sector.

Case Study 4: Nottingham Geospatial Institute

The Nottingham Geospatial Institute (NGI) at the University of Nottingham is a pioneering centre for education and research in geospatial technologies, including Earth observation, positioning, and navigation. This unique institute operates as a cross-cutting research group, spanning multiple departments within the Faculty of Engineering. The NGI's approach to teaching is characterised by its integration of space-related technologies and concepts across various engineering disciplines, providing students with a comprehensive understanding of geospatial applications in their primary fields of study.

The institute's educational offerings range from undergraduate courses to doctoral programmes, all designed to equip students with both theoretical knowledge and practical skills essential for the evolving space and geospatial sectors. At the undergraduate level, the NGI incorporates geospatial concepts into the existing engineering curriculum, ensuring that students in fields such as chemical, environmental, and civil engineering gain exposure to space applications relevant to their disciplines. This interdisciplinary approach is exemplified by the inclusion of geology courses for chemical engineering students, providing them with crucial knowledge about resource management and environmental considerations. Undergraduate civil engineering students are taught the theory and practice of engineering surveying using modern total stations and laser scanners. At the postgraduate level, the NGI runs a Centre for Doctoral Training (CDT) in partnership with Newcastle University, offering a four-year PhD program with significant industry involvement. This programme, which is training 50 PhD students across the two institutions, stands out for its comprehensive coverage of geospatial technologies and its extensive network of over 40 industrial partners; every studentship is linked to one or more such partner.

A cornerstone of the NGI's educational framework is its emphasis on hands-on learning experiences. Students engage in practical fieldwork, operate state-of-the-art surveying equipment, and participate in projects such as designing and building small satellites. These experiences are often supported by collaborations with industry partners, including arrangements with companies like Leica (Global manufacturer of high-end cameras and lenses, observation, and fine mechanical instruments), which provides access to cutting-edge surveying technology. The NGI's teaching philosophy is rooted in the belief that geospatial skills are increasingly crucial across various sectors. By consistently updating the curriculum with current research findings and maintaining strong industry connections, the institute strives to produce graduates who are not only well-versed in theoretical concepts but also prepared to apply their knowledge to real-world challenges in the space and geospatial industries.

Impact of work-integrated learning on skills development, talent retention, and productivity

The NGI's approach to work-integrated learning has significant positive impacts on skills development and industry readiness. By integrating space-related technologies across

various engineering disciplines, students gain exposure to real-world applications in their primary fields. This is exemplified by the chemical engineering student who worked on detecting plastics in the environment using space-based technologies, demonstrating the cross-disciplinary nature of skills developed. The hands-on experience gained through projects like building small satellites in aerospace engineering provides students with practical skills directly applicable to the space industry. This approach not only enhances technical skills but also develops problem-solving and teamwork abilities crucial for productivity in the sector.

The Masters programme integrated into the CDT's PhDs leads to placements in industry, and summer internships with university spin-out companies further bridge the gap between academic learning and industry application. These experiences likely contribute to talent retention in the Midlands space cluster by creating direct pathways from education to employment in the sector. The geology course for chemical engineering students provides practical skills relevant to resource management and environmental considerations, enhancing their industry readiness.

The Centre for Doctoral Training (CDT) at the Nottingham Geopatial Institute has trained 22 PhD students over the last five years, focusing on various aspects of geospatial technology including Earth observation, positioning, and navigation. The CDT model ensures that doctoral research is closely aligned with industry needs, incorporating placements and collaborative projects with partners ranging from national institutions to international universities. Students work on a wide range of topics within geospatial technology, contributing to diverse areas of the field.

Effective models and best practices for HE-industry collaboration:

The NGI's cross-cutting research group model, spanning multiple departments, emerges as an effective practice for fostering interdisciplinary collaboration and integrating space technologies across various engineering fields. This approach allows for a more comprehensive understanding of space applications across sectors. Space-related concepts are incorporated into existing courses rather than as standalone subjects, demonstrating an integrated approach to space education.

The collaboration with Leica for the surveying course demonstrates an effective model of industry partnership. By providing access to the latest equipment, this partnership ensures students are trained on industry-standard technology, enhancing their employability. The institute also participates in competitions like those organised by ESA, which provides opportunities for students to work on real-world space projects and potentially secure launches for their satellites. Research findings are incorporated into lectures, providing students with current, real-world examples and applications of the concepts they're learning.

The Centre for Doctoral Training (CDT) model, with its network of over 40 partners including universities, national institutions, large companies, and SMEs, showcases a best practice in creating a diverse and flexible approach to industry collaboration. The range of involvement, from providing seminars to fully funding studentships, allows for

partnerships tailored to different industry capacities and needs. The programme includes international partnerships with universities in Europe, North America, and Australia, offering global exposure to students.

Actionable recommendations and practical tools

Based on the insights from the Nottingham Geospatial Institute, several recommendations and practical tools have been identified to enhance the effectiveness of similar initiatives across educational institutions, industry, and policymakers.

Educational institutions should consider adopting a cross-cutting research group model similar to NGI's approach. This model allows for the integration of space-related technologies and concepts across various engineering disciplines, providing students with a comprehensive understanding of geospatial applications in their primary fields of study. Institutions should also prioritise the incorporation of hands-on learning experiences into their curriculum. This could involve practical fieldwork, operation of state-of-the-art surveying equipment, and participation in projects such as building small satellites. These experiences provide students with invaluable practical skills directly applicable to the space industry.

The development of integrated Masters programmes with links to industry should also be encouraged. This approach bridges the gap between academic learning and industry application, enhancing students' industry readiness and employability. Institutions should continue to expand and strengthen Centres for Doctoral Training (CDT) in partnership with other universities and industry partners. While such collaborations are already happening, there is room for further development and enhancement. The CDT model ensures that doctoral research is closely aligned with industry needs and provides comprehensive coverage of specialised fields like geospatial technologies. By building upon existing partnerships and seeking new opportunities for collaboration, institutions can further strengthen the links between academia and industry, creating more robust pathways for students to transition into the space sector workforce. This ongoing effort to refine and expand CDT initiatives can lead to even greater alignment between research outputs and industry requirements, ultimately benefiting both students and the wider space sector ecosystem.

Industry partnerships for equipment access and training should be actively pursued. Collaborations like NGI's arrangement with Leica for surveying equipment ensure students are trained on industry-standard technology, enhancing their employability. Companies should be encouraged to provide a range of engagement options with educational programmes. This could include offering seminars, sponsoring projects, providing internships, or fully funding studentships. Such flexibility allows for partnerships tailored to different industry capacities and needs. Industry partners should also be involved in curriculum development to ensure that course content remains current and relevant to sector needs. This could involve regular consultations, guest lectures, or participation in advisory boards.

Policymakers should support the development of cross-disciplinary space education initiatives. This effort could be led by the UK Space Agency (UKSA) in collaboration with the Department for Education (DfE), with support from universities and research councils. Funding and resources should be allocated to programmes that demonstrate the integration of space technologies across various engineering and scientific disciplines, potentially overseen by UK Research and Innovation (UKRI). The creation of a national framework for industry-academia collaboration in the space sector should be considered, possibly spearheaded by the Department for Business and Trade (DBT) with input from UKSA and Universities UK. This framework could provide guidelines, best practices, and potentially financial incentives for effective partnerships. Support should be provided for the participation of UK universities in international space education initiatives and competitions. This could involve funding for student projects in competitions like those organised by ESA, enhancing the global competitiveness of UK space education. The UKSA could take the lead in coordinating these international efforts. Policymakers should also consider establishing a national space education and research network. This network could be led by an expanded Space Universities Network (SUN) and could facilitate knowledge sharing, resource pooling, and collaborative projects between different institutions and regions, strengthening the overall space education ecosystem in the UK. To ensure effective implementation, a Space Education Policy Taskforce comprising representatives from these lead organisations could be formed to oversee and coordinate these various initiatives.

Case Study 5: University of Leicester

The University of Leicester stands as a pioneering institution in space education, with a rich history dating back to 1992 when it first introduced formal space science degrees. Today, it offers a comprehensive range of space-related programmes that span multiple departments, including Physics and Astronomy, Geography, Geology and Environment, and Engineering.

At the undergraduate level, Leicester provides specialised courses such as physics with space science, astrophysics, and planetary science. These programmes offer a solid foundation in physics while incorporating space-specific modules. The undergraduate offerings include both BSc and MPhys degrees, with the MPhys being an integrated masters programme at the same level as an MSc. The university's postgraduate offerings further expand on this foundation with three distinct Masters programmes: Space Exploration, Space Data, and Space Engineering. The Space Data Masters programme is particularly popular, boasting up to 80 students per year, while the Space Exploration Masters typically hosts 20-30 students. It's important to note that many of the features traditionally associated with MSc programmes, such as working with industry through projects and internships, are also integral components of the BSc and MPhys programmes. This approach ensures that students at all levels benefit from practical, industry-relevant experience throughout their studies.

Leicester's space education is distinguished by its strong emphasis on industry collaboration and practical experience. The university's Space Park Leicester serves as a unique asset, fostering a vibrant space cluster that attracts companies and creates opportunities for students to engage with industry partners. This engagement takes various forms, from formal internships and industry projects to informal events like open talks and monthly "cosmic coffee" sessions. The university also offers Continuing Professional Development (CPD) courses, diplomas, and certificates, providing flexible options for professionals looking to transition into or advance within the space sector. These programmes demonstrate Leicester's commitment to lifelong learning and industry-relevant education.

Impact of work-integrated learning on skills development, talent retention, and productivity in the Midlands space cluster

The University of Leicester offers a comprehensive range of space-related undergraduate and postgraduate programmes that incorporate industry-relevant components. Their Masters programmes are designed to produce "oven-ready" graduates who can easily transition into industry roles. Both undergraduate and postgraduate students benefit from industry projects that provide real-world experience. Students have access to industry-standard equipment and software, such as CAD tools, which enhances their practical skills. The university maintains a regular flow of interns to industry partners, including summer job opportunities, further strengthening the connection between education and industry. The university's international

collaborations, particularly in its Masters programs, further enhance its global profile and provide students with valuable exposure to the international space community.

Leicester's long history of offering formal space science degrees has resulted in many graduates populating the UK space industry. Several high-profile graduates now hold leadership positions in companies like BAE Systems, Planet, and the UK Space Agency, demonstrating the long-term impact of their education programs. To further support skills development, the university offers Continuing Professional Development (CPD) courses, diplomas, and certificates, providing additional avenues for professionals to enhance their expertise in the space sector.

Effective models and best practices for HE-industry collaboration

Space Park Leicester has emerged as a catalyst for the local space sector, fostering a vibrant ecosystem that attracts companies and nurtures collaboration. By formalising relationships with co-located businesses, the park has strengthened industry partnerships, leading to enhanced opportunities for students. This synergy is particularly evident in the development of real-world projects for Masters-level students, where industry partners and the university collaborate closely.

The integration of shared facilities, both within Space Park and across the university campus, has proven invaluable for student project work. A prime example of this collaborative approach is the Space Exploration Masters programme, which extends beyond national borders to involve partnerships with universities in Europe and the United States. This international cooperation not only enriches the educational experience but also elevates the global profile of the universities' activities.

The university's impact extends beyond its immediate campus, thanks to a strong partnership with the city council. This collaboration has led to the provision of complementary facilities, such as incubator buildings, which further support the growth of the space sector. The concept of "Space City" has evolved from this partnership, encompassing the enterprise zone and exerting a broader influence on the local community.

To further bridge the gap between academia and industry, the university offers a range of informal engagement opportunities. These include open talks, meetings, and a monthly "cosmic coffee" event, all designed to facilitate networking and knowledge exchange. Moreover, the university's commitment to wider community impact is evident in its outreach programmes. By organising events specifically tailored for local schools, with a particular focus on those in economically disadvantaged areas of the city, the university is actively working to broaden the reach and impact of space education. Through targeted mentorship programmes, role model presentations, and hands-on workshops, the university is striving to break down barriers and showcase the diversity of opportunities within the space sector. This concerted effort not only aims to inspire the next generation of space professionals and enthusiasts but also to cultivate a more inclusive and representative future workforce in the space industry. These initiatives are intentionally structured to promote diversity and inclusion, ensuring representation from

underrepresented groups in the space sector, particularly women and ethnic minorities By prioritising diversity and inclusion in both its engagement and outreach activities, the university is taking proactive steps to address gender and ethnic disparities in the field, thereby enriching the talent pipeline and fostering innovation through diverse perspectives.

Actionable recommendations and practical tools

Based on the insights from the University of Leicester's space education programmes and initiatives, several recommendations and practical tools have been identified to enhance the effectiveness of similar initiatives across educational institutions, industry, and policymakers.

Educational institutions should consider developing a comprehensive range of space-related programmes that span multiple departments. This approach, as demonstrated by Leicester's offerings across Physics and Astronomy, Geography, Geology and Environment, and Engineering, provides students with a holistic understanding of the space sector. However, it's crucial to note that not all universities necessarily need to adopt the same approach. A key finding of this report is the value inherent in the diversity of approaches taken by different institutions. Each university can leverage its unique strengths, resources, and regional context to contribute distinctively to the space education landscape. Some may excel in specific niche areas, while others might offer broader, interdisciplinary programmes. This variety in educational offerings not only caters to diverse student interests and industry needs but also fosters innovation and specialisation across the sector. The richness of this educational ecosystem lies in its ability to produce graduates with varied skill sets and perspectives, ultimately strengthening the UK's space sector as a whole.

Institutions should also strive to create specialised undergraduate courses that combine foundational sciences with space-specific modules. This approach allows students to gain a solid scientific background while developing expertise in space-related areas. Additionally, the development of diverse postgraduate programmes tailored to different aspects of the space sector should be prioritized. Leicester's model of offering distinct Masters programmes in Space Exploration, Space Data, and Space Engineering caters to various industry needs and student interests.

Educational institutions should work towards formalising relationships with co-located companies in space-focused facilities. This approach can lead to stronger industry partnerships and enhanced opportunities for students. The development of real-world projects for students, particularly at the Masters level, should be done in close collaboration with industry partners. This ensures that students work on relevant, current challenges in the space sector. Institutions should consider offering a range of engagement opportunities with industry, from formal internships to informal events like open talks and networking sessions. Leicester's "cosmic coffee" event provides an excellent model for casual industry-student interaction. Furthermore, the creation of Continuing Professional Development (CPD) courses, diplomas, and certificates should be explored to provide flexible options for professionals in the space sector. These

offerings can help address specific skills gaps and support lifelong learning in the rapidly evolving space industry.

Policymakers should support the development of "Space City" concepts that extend beyond university campuses. This could involve collaborating with local councils to provide complementary facilities like incubator buildings and enterprise zones, fostering the growth of regional space clusters. Funding should also be allocated to support international collaborations in space education programmes. These partnerships, such as those in Leicester's Space Exploration Masters programme, enhance the global profile of UK space activities and provide students with valuable international exposure.

Policies should also be developed to incentivise industry participation in space education programmes. This could include tax breaks for companies that offer internships, sponsor student projects, or contribute to curriculum development. Support should be provided for outreach programmes targeting schools in economically disadvantaged areas. This can help broaden the impact of space education and inspire a more diverse next generation of space professionals.

Discussion

The analysis of the four case studies from the Midlands space cluster - University of Birmingham, University of Warwick (WUSAT), Nottingham Geospatial Institute (NGI), and University of Leicester - reveals several consistent themes and notable differences in their approaches to space education and industry collaboration. This discussion will assess these findings in the context of the project's aims.

Impact of work-integrated learning on skills development, talent retention, and productivity

The impact of work-integrated learning on skills development, talent retention, and productivity is evidenced across the four institutions examined, each demonstrating a unique approach to integrating industry experience with academic learning in space-related fields.

The University of Leicester stands out with its long history and comprehensive range of programmes from undergraduate to postgraduate levels, including popular Masters programs in Space Exploration, Space Data, and Space Engineering. Their approach encompasses industry projects, internships, and access to industry-standard equipment, particularly through Space Park Leicester. This aligns with research indicating that collaboration between educational institutions and employers is crucial for providing students with valuable work experience, enhancing their future employability and understanding of the professional world (O Regan and Bhattacharya, 2023).

The University of Birmingham's MSc Space Engineering programme, while newer and smaller in scale, focuses intensively on industry-relevant skills, particularly in areas like radio frequency engineering and materials science for space applications. The programme's small cohort size allows for tailored learning experiences and close collaboration with industry partners. This approach resonates with findings that successful work-integrated learning (WIL) programmes are enabled by collaboration between universities and industry partners, providing authentic contexts for students to develop both technical and transferable skills (Hansberry and Gerhardt, 2023).

Warwick's WUSAT program takes a unique approach by integrating satellite development into the curriculum, providing students with end-to-end experience in satellite design and construction. This hands-on, multidisciplinary approach closely mirrors real-world industry practices, again exemplifying the kind of authentic learning context that research has shown to be effective in developing both technical and critical transferable skills (Hansberry and Gerhardt, 2023).

The Nottingham Geospatial Institute stands out for its cross-cutting approach, integrating space-related technologies across various engineering disciplines. This model ensures that students in diverse fields gain exposure to space applications, broadening the potential talent pool for the space sector. This is important in bringing

diversity to the talent pool because of the range of perspectives from the different disciplines. This aligns with the growing recognition that traditional education models may no longer be sufficient to meet the demands of an ever-evolving job market, and that WIL is becoming increasingly important to ensure learners are equipped with the most relevant and up-to-date skills (Scottish Government, 2023; Kelly, 2020).

In terms of talent retention, all programmes show promise, with graduates securing positions in the space sector. Leicester's and Warwick's long history has resulted in numerous alumni in leadership positions across the UK space industry. Birmingham, despite its smaller and newer programs, has also seen graduates enter the space sector. Meanwhile, NGI's approach of integrating space technologies across disciplines contributes to a broader application of space-related skills in various sectors. This diversity of approaches underscores a crucial point: while learning from each other is valuable, institutions need not replicate one another's strategies. Instead, each institution should strive to find its own unique place within the regional skills ecosystem. This approach allows universities to complement rather than compete with each other, creating a rich tapestry of educational offerings that cater to varied industry needs and student aspirations. By carving out their own niches, whether through specialised research areas, innovative teaching methods, or unique industry partnerships, institutions can contribute more effectively to the overall growth and diversification of the space sector workforce. This tailored approach not only enhances the resilience of the regional skills pipeline but also ensures that the collective output of these institutions meets the multifaceted demands of the evolving space industry.

While these programmes demonstrate the positive impact of work-integrated learning, it is important to note that implementing such programs comes with challenges. These may include coordination with industry partners, ensuring relevance of projects, and managing student expectations. For example, WUSAT operates with limited funding and relies heavily on industry partnerships and the dedication of its leadership. The programme faces challenges in terms of continuity between academic years and integration with traditional university research structures.

In conclusion, the examined institutions showcase various effective models of work-integrated learning in space-related fields. Their approaches, while different in scale and specifics, all contribute to developing industry-ready graduates and fostering closer ties between academia and the space sector. As the space industry continues to evolve, these WIL programs play a crucial role in ensuring a skilled and adaptable workforce.

Effective models and best practices for HE-industry collaboration

Each institution has developed unique models for industry collaboration, demonstrating the diverse approaches to work-integrated learning in the space sector. These models align with research emphasising the importance of collaboration between educational institutions and employers in providing students with valuable work experience (O Regan and Bhattacharya, 2023).

Leicester's Space Park stands out as a physical hub for industry-academia interaction, fostering a local space cluster. Their collaboration with the city council in developing the "Space City" concept demonstrates effective engagement with local government. This approach exemplifies the deep consultation with a broad range of stakeholders that Walker (2021) identifies as vital for ensuring educational provision matches local needs.

Birmingham's use of an Industrial Advisory Board and industry-supported projects, though on a smaller scale, ensures curriculum relevance and provides students with industry exposure. Meanwhile, Warwick's WUSAT program's long-term project structure and collaborations with major industry players like Airbus offer a different model of sustained industry engagement.

NGI's Centre for Doctoral Training, with its extensive network of over 40 industrial partners, provides a comprehensive model for industry collaboration at the postgraduate level. Their approach of integrating space technologies across various engineering disciplines also offers a unique perspective on industry collaboration. This cross-cutting approach aligns with the growing recognition that traditional education models may need to evolve to meet the demands of an ever-changing job market (Scottish Government, 2023; Kelly, 2020).

All four institutions emphasise the importance of practical, hands-on experience, whether through projects, internships, or access to industry-standard equipment. They also all maintain strong alumni networks, which serve as valuable resources for current students and industry connections. These networks contribute to the broader ecosystem of industry-academia collaboration, potentially addressing some of the challenges in coordinating partnerships between universities and industry partners identified by Robson (2023).

While these models demonstrate effective industry collaboration, it is important to note that challenges exist in implementing such programs. These may include resource constraints, coordination difficulties, and the need for long-term commitment from both academic institutions and industry partners. However, the potential benefits in terms of skills development, industry relevance, and graduate employability appear to outweigh these challenges.

Actionable recommendations and practical tools

Drawing on insights from the University of Leicester, Nottingham Geospatial Institute (NGI), WUSAT (Warwick University Satellite Team), and the University of Birmingham, this summary presents a holistic set of recommendations for enhancing space education and industry collaboration in the UK. These recommendations are grounded in the experiences of the institutions studied and align with broader research on work-integrated learning.

Cross-Cutting Recommendations

1. **To provide a comprehensive space education, institutions should develop a mix of specialised and interdisciplinary approaches.** It's crucial to note that not all universities necessarily need to adopt the same approach. A key finding of this report is the value inherent in the diversity of approaches taken by different institutions. Each university can leverage its unique strengths, resources, and regional context to contribute distinctively to the space education landscape. Some may excel in specific niche areas, while others might offer broader, interdisciplinary programmes. This variety in educational offerings not only caters to diverse student interests and industry needs but also fosters innovation and specialisation across the sector. The richness of this educational ecosystem lies in its ability to produce graduates with varied skill sets and perspectives, ultimately strengthening the UK's space sector as a whole.
2. **Industry-integrated learning should be a core component of space education programmes.** The University of Birmingham ensures close industry engagement through its Advisory Panel, while WUSAT engages students in long-term, industry-relevant satellite development projects. The University of Leicester facilitates collaboration with industry partners for real-world projects at the Masters level, and NGI implements integrated Masters programmes with a year in industry.
3. **Hands-on experience is crucial for developing practical skills.** The University of Birmingham creates on-campus industry-standard testing environments to simulate real-world conditions, while NGI offers practical fieldwork and operation of state-of-the-art surveying equipment. The University of Leicester provides access to facilities at Space Park Leicester, and WUSAT engages students in building small satellites.
4. **Diverse postgraduate offerings cater to various aspects of the space sector.** NGI established Centre for Doctoral Training (CDT) in partnership with other universities, while the University of Leicester offers distinct Masters programmes in Space Exploration, Space Data, and Space Engineering. The University of Birmingham has a specialised courses in emerging areas like space debris management to address specific industry needs, and WUSAT focuses on long-term, multiyear project experiences.
5. **Emphasis on developing soft skills is essential for producing well-rounded professionals.** While technical expertise is crucial in the space sector, the ability to communicate effectively, work in diverse teams, manage projects, and think critically are equally important. Institutions should integrate soft skills development into their curricula through group projects, presentations, internships, and industry collaborations. For instance, WUSAT's multidisciplinary team approach naturally fosters communication and teamwork skills. The University of Birmingham's industry engagement initiatives provide opportunities for students to develop networking and professional communication skills. NGI's year in industry programme allows students to hone their adaptability and problem-solving skills in real-world contexts. A critical component of these soft skills is understanding and appreciating the high level of risks inherent in the space sector. Students should be trained to comprehend the complexities of risk assessment, mitigation strategies, and decision-making in high-stakes environments. This can be achieved through case studies of past space missions (both successful and failed), simulations of crisis scenarios, and guest lectures

from industry professionals who can share real-world experiences of managing risks in space projects. By explicitly focusing on these soft skills, including risk awareness and management, institutions can produce graduates who are not only technically proficient but also equipped with the interpersonal, cognitive, and risk-management skills necessary for leadership and innovation in the rapidly evolving and high-risk space sector.

Institution-Specific Innovations

1. **Collaborative spaces foster innovation and industry engagement.** The University of Leicester's Space Park serves as a hub for academia-industry collaboration, while NGI's cross-cutting research group model promotes interdisciplinary work. WUSAT proposes virtual mission control centres to enhance the student experience, and the University of Birmingham creates on-campus industry-standard testing environments.
2. **Knowledge transfer mechanisms ensure continuity and professional development.** WUSAT implements a structured system for knowledge transfer between student cohorts, while the University of Birmingham focuses on industry-informed curriculum development. NGI provides comprehensive coverage of geospatial technologies in doctoral training, and the University of Leicester offers CPD courses for professionals.
3. **Community engagement broadens the impact of space education.** The University of Birmingham and WUSAT focuses on addressing specific industry skills gaps through targeted programmes, while NGI participates in international competitions like those organised by ESA, and the University of Leicester reaches out to schools in economically disadvantaged areas.
4. **Resource sharing enhances educational opportunities and cost-effectiveness.** Institutions should establish mechanisms for sharing specialised equipment, facilities, and expertise across the Midlands space cluster. This could include creating a centralised database of available resources, implementing a booking system for shared equipment, and developing protocols for collaborative use of high-cost facilities. For instance, the University of Leicester's Space Park could offer access to its advanced laboratories to other institutions, while the University of Birmingham's industry-standard testing environments could be made available for joint research projects. Virtual resources, such as WUSAT's proposed mission control centres, could be designed for multi-institutional use. This approach not only maximises the utilisation of expensive resources but also promotes inter-institutional collaboration, exposing students and researchers to a wider range of cutting-edge tools and methodologies. Additionally, a resource-sharing framework could extend to human capital, facilitating guest lectures, joint supervision of research projects, and collaborative workshops across institutions.

Recommendations for Industry Engagement

1. **Flexible partnership models accommodate various levels of industry involvement.** The University of Leicester organises "cosmic coffee" events for informal networking, while NGI offers a range of engagement options from seminars to full studentship funding. WUSAT recommends implementing an

industry mentorship programme, and the University of Birmingham encourages active industry participation in curriculum development.

2. **Collaborative project development enhances the relevance of student work.** WUSAT supports industry-sponsored design challenges, while the NGI has established equipment access partnerships, and the University of Leicester facilitates industry-partnered projects at the Masters level.
3. **All four institutions recommend establishing formal industry advisory boards to guide curriculum development and ensure ongoing relevance to sector needs.** These boards serve as a crucial link between academia and industry, helping to align educational outcomes with evolving industry requirements.

Recommendations for Policymakers

1. **Sustained funding and support for regional development initiatives are crucial to strengthening the UK's space sector.** Policymakers should prioritise the continued development and expansion of projects such as Space Park Leicester, which serves as a hub for academia-industry collaboration.
2. **All institutions advocate for targeted funding initiatives for space education programmes that demonstrate strong industry collaboration and potential for regional economic impact.** Such funding can catalyse innovation and ensure the sustainability of cutting-edge space education programmes. This could include grants for equipment, industry secondments for academics, or support for student projects.
3. **Create incentives for regional space companies to engage with and hire from local educational programmes, such matching funds for internships and graduate positions, could boost local talent retention.**
4. **International collaboration enhances the global competitiveness of UK space education.** Policymakers should support the University of Leicester's international partnerships in space education and facilitate UK universities' participation in international space initiatives, as practiced by NGI.
5. **The development of national frameworks can streamline space education efforts across the UK.** NGI suggests creating a national space education and research network, while all institutions recommend developing incentives for industry participation in space education programmes.
6. **Supporting the development of a more cohesive Midlands space cluster would enhance collaboration opportunities between academia, industry, and research institutions.** The Midlands Space Cluster Initiative is important, as it works to create a robust ecosystem that enhances collaboration, drives innovation, and ensures the long-term growth space sector in the region.
7. **Effective policy implementation requires coordinated efforts at multiple levels of governance.** Local, regional, pan-regional, and national policymakers all have crucial roles to play in supporting the space sector's development. Local authorities can address specific local industry needs and facilitate direct university-industry collaborations. Regional bodies can coordinate larger-scale initiatives and ensure equitable development across their areas. National policymakers are essential for setting overarching strategies, providing substantial funding, and representing UK interests in international space collaborations.

8. **Pan-regional bodies play a vital role in fostering collaboration and coherence across wider geographical areas.** Organisations such as Midlands Innovation and the Midlands Aerospace Alliance (MAA) are uniquely positioned to bridge gaps between local initiatives and national strategies. These bodies can facilitate knowledge sharing, pool resources, and coordinate efforts across multiple institutions and regions, thereby enhancing the overall impact of space education and industry development initiatives. They can also serve as powerful advocates for the region's space sector interests at the national level.
9. **A multi-layered approach to policymaking ensures comprehensive support for the space sector.** While each level of governance has its specific role, collaboration between these levels is crucial. For instance, pan-regional bodies can help align local university programmes with national skills strategies, while national policymakers can use insights from regional initiatives to inform nationwide policies. This integrated approach can create a more resilient and adaptive policy environment that responds effectively to the dynamic needs of the space sector.

Conclusion

The analysis of work-integrated learning (WIL) initiatives in the Midlands space cluster reveals a dynamic and evolving landscape of space education and industry collaboration. The case studies from the University of Birmingham, University of Warwick (WUSAT), Nottingham Geospatial Institute (NGI), and University of Leicester demonstrate diverse approaches to addressing the skills gap and enhancing productivity in the space sector.

These institutions' activities complement the national Space Placements in INdustry (SPIN) programme, funded by the UK Space Agency and managed by the Satellite Applications Catapult. SPIN offers short-term project placements across various companies in the space sector, providing valuable industry exposure and practical experience to students from different disciplines and academic stages. This national initiative enhances the overall landscape of work-integrated learning in the UK space sector, offering additional opportunities for students to apply their knowledge in real-world settings and for companies to access fresh talent and ideas. The success of SPIN further underscores the value of work-integrated learning approaches in addressing the skills needs of the space industry and fostering collaboration between academia and industry on a national scale.

The four Midlands institutions collectively showcase the significant potential of WIL in developing industry-ready graduates, fostering innovation, and strengthening the links between academia and industry. This aligns with research emphasising the importance of collaboration between educational institutions and employers in providing students with valuable work experience (O Regan and Bhattacharya, 2023). The impact of these programmes on skills development is evident across all case studies, with students gaining practical, industry-relevant experience that complements their theoretical knowledge. This hands-on approach, whether through satellite development projects, industry placements, or cross-disciplinary applications of space technologies, is proving effective in preparing students for the unique challenges of the space sector.

Early indicators for talent retention and productivity are promising, with graduates securing positions within the space sector both regionally and nationally. This success resonates with findings that "experience seekers" and "early movers" who harness the dynamic of learning through work see experience accounting for a significant portion of their lifetime earnings (Madgavkar, 2022). The long-term impact of Leicester's established programmes and the emerging influence of newer initiatives at Birmingham suggest a positive trajectory for talent retention in the Midlands space cluster.

A common thread running through these programmes is the crucial role of individual leadership in their inception, development, and ongoing success. The MSc Space Engineering Programme at the University of Birmingham, launched in 2023, reflects the foresight of its academic leader who recognised the need for specialised space engineering education aligned with industry needs. The Warwick University (WUSAT) programme, running since 2006, stands as a testament to the long-term commitment and vision of its leadership, persevering for nearly two decades. The Nottingham

Geospatial Institute (NGI) at the University of Nottingham exemplifies how strong leadership can create a cross-cutting research group that integrates space-related technologies across multiple engineering disciplines. Finally, the University of Leicester's space education programmes, showcase how sustained leadership over decades can build a comprehensive ecosystem of space education, with the recent development of Space Park Leicester further demonstrating how visionary leadership can create physical spaces that catalyse industry-academia collaboration. These case studies highlight how individual leaders within academic institutions, often working in close collaboration with industry partners and policymakers, have been instrumental in identifying opportunities, securing resources, and driving the development of innovative space education initiatives.

The research has identified several other best practices for HE-industry collaboration. These include the development of physical hubs like Space Park Leicester, the use of Industrial Advisory Boards, long-term project structures, and extensive networks of industrial partners. The flexibility and diversity of these approaches highlight the importance of tailoring collaboration models to specific institutional strengths and local contexts. These approaches align with recommendations for deep consultation with a broad range of stakeholders to ensure educational provision matches local needs (Walker, 2021).

Key recommendations emerging from this research provide a roadmap for enhancing the effectiveness of WIL in the space sector:

1. **Adopt a mixed approach to space education**, as demonstrated by all four institutions. This includes integrating space-related technologies across various engineering disciplines (NGI), involving students from diverse backgrounds in space engineering projects (WUSAT), offering comprehensive programmes spanning multiple departments (Leicester), and developing specialised modules addressing specific skill gaps (Birmingham).
2. **Prioritise industry-integrated learning** through various means, such as long-term satellite development projects (WUSAT), industry advisory panels (Birmingham), collaboration on real-world projects at the Masters level (Leicester), and integrated Masters programmes with a year in industry (NGI).
3. **Provide hands-on experience** through access to state-of-the-art facilities and equipment, as seen in Space Park Leicester and NGI's surveying equipment partnerships.
4. **Develop diverse postgraduate offerings catering to various aspects of the space sector**, including specialised Masters programmes (Leicester), Centres for Doctoral Training (NGI), long-term project experiences (WUSAT), and courses addressing emerging industry needs (Birmingham).
5. **Create collaborative spaces that foster innovation and industry engagement**, such as Space Park Leicester, NGI's cross-cutting research group model and WUSAT's proposed virtual mission control centres.
6. **Implement knowledge transfer mechanisms to ensure continuity and professional development**, including structured systems for knowledge transfer between student cohorts (WUSAT), industry-informed curriculum development

(Birmingham), comprehensive doctoral training (NGI), and CPD courses for professionals (Leicester).

7. **Engage with the broader community to extend the impact of space education**, through outreach to schools in economically disadvantaged areas (Leicester), participation in international competitions (NGI), engagement with regional space cluster initiatives (WUSAT), and targeted programmes addressing industry skills gaps (Birmingham).
8. **Develop flexible partnership models with industry**, ranging from informal networking events to full studentship funding, and establish formal industry advisory boards to guide curriculum development.

For policymakers, recommendations include providing sustained funding and support for regional development initiatives such as Space Park Leicester and the Midlands Space Cluster Initiative, supporting international collaborations in space education, and developing national frameworks to streamline space education efforts across the UK. This funding should come from a variety of sources to ensure sustainability and diverse support. Potential funding avenues could include government agencies like the UK Space Agency and relevant departments, research councils such as UKRI, regional cluster funds, and industry partnerships. By diversifying funding sources, the sector can build a more resilient financial base and create a network of stakeholders invested in the success of these initiatives. Policymakers should work to facilitate access to these various funding streams and create frameworks that encourage multi-stakeholder investment in the UK's space education and industry development.

However, significant challenges remain, particularly in light of the unique risks and demands of the space sector. The industry faces critical skills shortages in areas such as software development, systems engineering, and radio-frequency specialisation. Moreover, there is a pressing need for professionals who not only possess technical skills but also understand the extreme and unique risks inherent in space operations, including launch safety, satellite infrastructure costs, and harsh space environments. Looking forward, the recommendations emerging from this research provide a roadmap for enhancing the effectiveness of WIL in the space sector. The emphasis on flexible partnership models and addressing funding challenges through diversified sources is crucial for the sustainability and growth of these initiatives. These align with policy recommendations for increased funding for WIL initiatives and creating more flexible learning pathways (Parliamentary Office of Science and Technology, 2021).

In conclusion, the Midlands space cluster demonstrates a robust and innovative approach to space education and industry collaboration through WIL. While each institution has developed unique strategies, the overarching commitment to practical, industry-aligned education is consistent. As these programmes continue to evolve and expand, their potential to significantly impact the productivity and competitiveness of the UK space sector becomes increasingly evident.

By continuing to refine and expand these WIL approaches, the Midlands space cluster is well-positioned to play a pivotal role in driving innovation, productivity, and growth in the

UK space sector, while also addressing the complex challenges that have historically constrained the industry's potential.

Future Research and Broader Perspectives

While this study has focused on university-level education in the Midlands space cluster, future research should broaden its scope to encompass the entire educational ecosystem supporting the space sector. A key area for further investigation is the role of Further Education (FE) institutions, non-degree routes, and degree apprenticeships in addressing the sector's skills needs. These alternative pathways may offer unique advantages in terms of flexibility, industry alignment, and addressing specific skills gaps, and thus warrant in-depth study alongside university programmes. This expanded focus could provide a more comprehensive understanding of the skills pipeline feeding into the space industry.

It's worth noting that the scope of the current project had to be narrowed due to unforeseen circumstances, including a period of maternity leave. There is significant interest in revisiting and expanding this research upon return in November 2025, to capture a more holistic picture of space education in the Midlands and beyond.

Furthermore, recent developments underscore the importance of digital skills across various sectors, including space. A report published by Skills England (Skills England report: driving growth and widening opportunities - GOV.UK, 2023) highlights the crucial role of digital skills in driving growth and widening opportunities. This aligns closely with the needs of the space sector, where software development, data analysis, and digital systems management are increasingly vital. Future research should explore how space education programmes are integrating these critical digital skills into their curricula and how this integration impacts graduates' readiness for the evolving demands of the space industry.

Additionally, further investigation is needed into how Work Integrated Learning (WIL) can specifically address the unique risks and safety concerns of the space sector. This research should aim to ensure that graduates are not only technically proficient but also well-versed in critical risk management aspects of space operations, including launch safety, satellite infrastructure costs, and the challenges posed by harsh space environments.

By expanding the scope of research to include these broader perspectives, we can gain a more comprehensive understanding of the entire space education ecosystem. This holistic approach will be crucial in developing strategies to address skills gaps, enhance industry readiness, and ultimately drive innovation and growth in the UK space sector.

References:

1. Anwar, T. and Ramaiah, B. (2024) Higher Technical Qualifications: how to liberate employers and skill workers for the future. Available at: https://ow.ly/8B7C50QpblY (Accessed: September 2024).
2. Billing, C.A. and Bryson, J.R. (2019) 'Heritage and satellite manufacturing: firm-level competitiveness and the management of risk in global production networks', Economic Geography, 95(5), pp. 423-441.
3. Billing, C.A., Bryson, J.R. and Kitsos, T. (2024) 'Industrial path development in the UK space sector: processes of legitimacy building in the establishment of Space 2.0', Industry and Innovation, pp. 1-26.
4. British Chambers of Commerce (2021) Report of the Workplace Training and Development Commission. Available at: https://britishchambers.org.uk/wp-content/uploads/2023/09/Workplace-Training-and-Development-Commission-Report.pdf (Accessed: September 2024).
5. Clayton, N. and Evans, S. (2021) Learning at work: employer investment in skills. Available at: https://learningandwork.org.uk/resources/research-and-reports/learning-at-work-employer-investment-in-skills/?platform=hootsuite (Accessed: September 2024).
6. Coyle, D. (n.d.) The productivity agenda report. Available at: https://www.productivity.ac.uk/research/the-productivity-agenda-report/ (Accessed: September 2024).
7. Edwards, M. (2024) Upskilling the nation: strengthening the UK's labour force. Available at: https://www.lifelongeducation.uk/_files/ugd/5e41e6_60090560a6c94825a576ec2ebf2c7ad1.pdf (Accessed: September 2024).
8. Evans, S. (2023) Time to learn: increasing participation in learning. Available at: https://learningandwork.org.uk/resources/research-and-reports/time-to-learn/ (Accessed: September 2024).
9. Ferguson, G. (2022) The importance of workplace learning for social workers. Available at: https://www.iriss.org.uk/sites/default/files/2022-12/insights-67.pdf (Accessed: September 2024).
10. Gov.UK (2022) Size & health of the UK space industry 2022. Available at: https://www.gov.uk/government/publications/the-size-and-health-of-the-uk-space-industry-2022/size-health-of-the-uk-space-industry-2022 (Accessed: September 2024).
11. Green, A. and Taylor, A. (2020) Workplace Perspectives on Skills. Available at: https://pure-oai.bham.ac.uk/ws/portalfiles/portal/225986203/Workplace_Perspective_on_Skills_-_April_2020.pdf (Accessed September 2024).
12. Hall, S., Jones, E. and Evans, S. (2022) Adult participation in learning survey Available at: https://learningandwork.org.uk/wp-content/uploads/2022/11/Adult-Participation-in-Learning-Survey-2022.pdf (Accessed: September 2024).
13. Hansberry, P. and Gerhardt, T. (2023) 'A tripartite understanding of experiences of young apprentices: a case study of the London Borough of Hounslow', International Review of Education, pp. 1-32.

14. International Longevity Centre UK (2024) Redefining lifelong learning: lessons from around the globe. Available at: https://ilcuk.org.uk/wp-content/uploads/2024/02/Final-copy-lifelong-learning-report.pdf (Accessed: September 2024).
15. Kelly, D. et al. (2020) Upskilling Scotland: the future of skills and the fourth industrial revolution. Available at: https://www.scdi.org.uk/wp-content/uploads/Upskilling-Scotland-The-Future-of-Skills-and-the-Fourth-Industrial-Revolution.pdf (Accessed: September 2024).
16. Madgavkar, A. et al. (2022) Human capital at work: the value of experience. Available at: https://www.mckinsey.com/capabilities/people-and-organizational-performance/our-insights/human-capital-at-work-the-value-of-experience (Accessed: September 2024).
17. O Regan, N. and Bhattacharya, A. (2023) Learning from experience: how to make high quality work experience for all a reality. Available at: https://www.smf.co.uk/wp-content/uploads/2023/03/Learning-from-experience-March-2023.pdf (Accessed: September 2024).
18. Parliamentary Office of Science and Technology (2021) Upskilling and retraining the adult workforce. Available at: https://researchbriefings.files.parliament.uk/documents/POST-PN-0659/POST-PN-0659.pdf (Accessed: September 2024).
19. Plant, H. and Stevenson, A. (2022) Review of national strategies for adult basic skills: report and case studies. Available at: https://learningandwork.org.uk/wp-content/uploads/2022/10/National-Strategies-for-Adult-Basic-Skills.pdf (Accessed: September 2024).
20. Robson, J. (2023) The skills revolution: can lifelong learning save the UK economy? Available at: https://skope.ox.ac.uk/wp-content/uploads/2023/11/SKOPE-Working-Paper-skills-revolution.pdf (Accessed: September 2024).
21. Scottish Government (2023) Adult lifelong skills: a literature review. Available at: https://www.gov.scot/binaries/content/documents/govscot/publications/research-and-analysis/2023/04/adult-lifetime-skills-literature-review/documents/adult-lifetime-skills-literature-review/adult-lifetime-skills-literature-review/govscot:document/adult-lifetime-skills-literature-review.pdf (Accessed: September 2024).
22. UK Space Agency (2023) Space Sector Skills Survey 2023. Available at: https://assets.publishing.service.gov.uk/media/650078401886eb0013977223/Space_Sector_Skills_Survey_2023_final2.pdf (Accessed: September 2024).
23. Walker, T. (2021) Striking a balance: engaging employers in the skills system to achieve better outcomes for learners. Available at: https://www.lancaster.ac.uk/media/lancaster-university/content-assets/documents/lums/work-foundation/reports/Strikingabalance.pdf (Accessed: September 2024).
24. Young, K. and Rooney, D. (2023) 'Developing soft (employability) skills and work experience opportunities to prepare students with intellectual disability for open employment', British Journal of Special Education, 50(4), pp. 1-13.