A NEW REALITY:
Immersive Learning in Construction

Full Report

The second in a series of
CITB Research Reports on
Productivity and Future Skills
September 2017

CONTENTS

CONTENTS

FOREWORD

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One of the biggest challenges facing the construction sector is modernisation.

The title of 2016's Farmer Review – Modernise or Die – highlighted this challenge in no uncertain terms.

For the sector to truly modernise, we need to embrace innovative and digital forms of training - most prominently, Immersive learning, the theme of this report.

As Co-Chair of the Construction Leadership Council (CLC) I work with industry and government to support UK construction in building greater efficiency, skills and growth.

I am very pleased to present this report as it lays down the gauntlet for employers, trainers and the Government to tackle these key issues through innovation.

As this report says, immersive learning can revolutionise training delivery, help produce 'work-ready' employees and transform the perception of the sector to investors and young people.

This latter point is crucial because if the construction sector is to thrive we need to attract as much talent as soon as possible.

I was interested to read that for some young people consulted during the research for this report, construction was still seen as a dirty, low-paid, manual occupation that lacks opportunities to learn through state-of-the-art technology.

This is a perception that needs to change – and quickly.

The future of this industry depends on having a skills base that is equipped to meet the challenges of productivity, as well as competition from international and cross-sector disruptors. The industry is shifting towards more digital design, more offsite manufacture and smarter assets. We need to attract and develop a workforce to meet these challenges.

The case studies in this report – early examples of immersive learning best practice – demonstrate how technology can improve the industry's image by showcasing construction as a future-focused sector. This is important to a new generation who have been brought up using gaming and virtual environments.

The evidence for immersive learning to provide more sophisticated, exciting and cost-effective training is also compelling. For me, one of the key words in this report is collaboration.

It is clear that industry, trainers and the Government need to collaborate to improve understanding of what immersive learning is, increase expertise and avoid fragmented development.

This report highlights the need to encourage take-up, standardise approaches and encourage collaboration between sectors, such as gaming, to develop successful applications.

I would like to record the Council's gratitude to the Construction Industry Training Board and all those who collaborated on this report for highlighting the potential immersive learning has to offer – and the challenges that lie ahead.

I hope everyone in the construction sector can work together to realise the exciting opportunities immersive learning can present.

Andrew Wolstenholme OBE
Co-Chair, Construction Leadership Council

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

This report, the first of its kind for the construction industry, explores the benefits and challenges of providing immersive learning.

Immersive learning – the use of digital technologies such as virtual and augmented reality – has the potential to revolutionise training delivery and transform the perception of the construction sector to young people and investors.

Immersive learning allows students to be fully involved in an interactive, digital environment. It means trainees can, for example, practice crane manoeuvres, scale wind turbines, or visualise the detailed 3D build of a skyscraper – without leaving the classroom.

For employers, immersive learning can produce more able, 'work-ready' employees, be cost-effective and help reduce the skills shortage by attracting more young people to construction.

For trainers, immersive technology can free up capacity, making student assessments swifter and allow trainers more time to focus on skills development.

For trainees, immersive learning offers a stimulating and quick way to learn.

For government, this new form of learning offers a chance to improve the quality, efficiency and safety of construction workers.

For construction as a whole, immersive learning can help develop the skills and attract the talent it needs to innovate, modernise, become more productive and deliver on the aims of the Sector Deal on which the Construction Leadership Council is working.
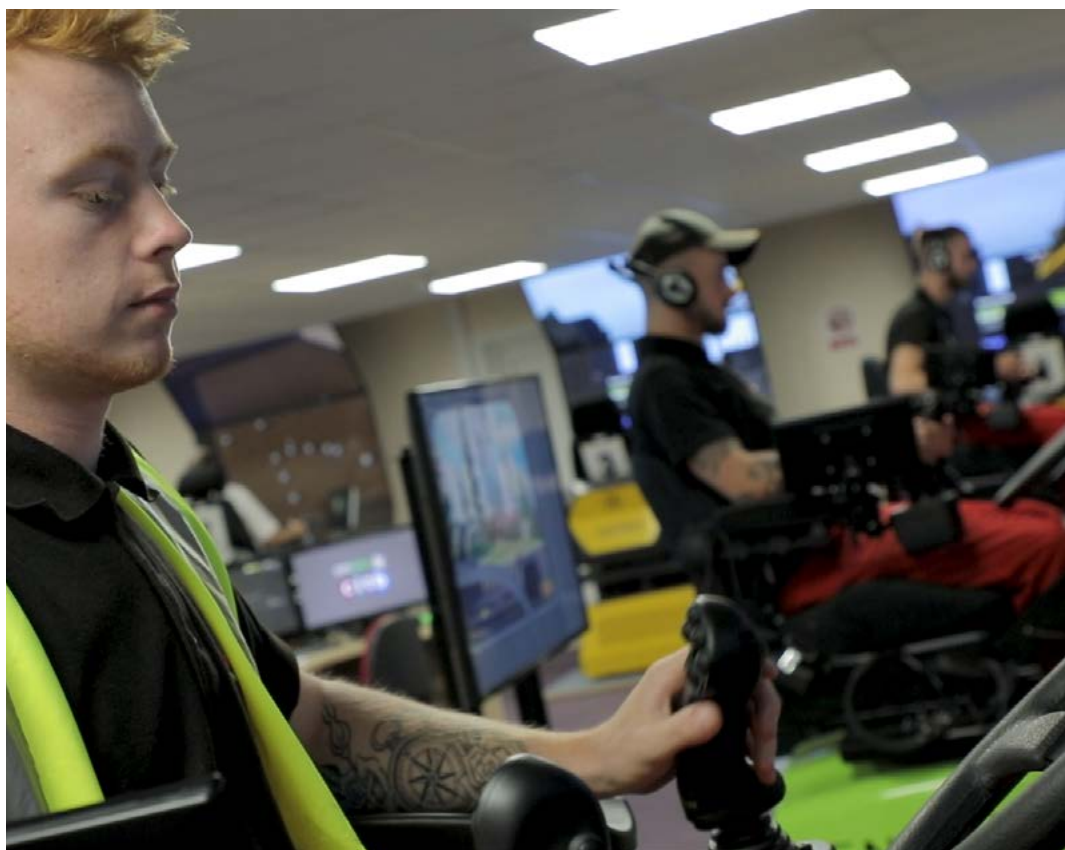
Our report showcases best practice in the adoption of immersive learning and highlights the need to encourage take up, standardise approaches and collaboration between sectors such as gaming to develop successful applications.

To realise immersive learning's potential, a number of challenges must be addressed, including improved employer understanding of what immersive learning is, increased expertise and avoid fragmented development.

ABOUT THIS REPORT

The research method for this project was qualitative and multi-phased and consisted of:

- 36 in-depth interviews with stakeholders across the industry and three nations to explore their current understanding of immersive learning/technology, how and where it could be applied and potential barriers to understanding

- 10 nationwide case study visits to sites using immersive technology in different capacities to understand in greater detail how, where and why they have been applying immersive learning – including barriers to implementation, technological, structural and cultural

This research includes the viewpoints of several federations and other stakeholders.

What is immersive learning?

An approach to learning which uses digital technologies, such as virtual and augmented reality, to better engage learners through an interactive learning environment. This involves using game based techniques (such as collaboration, communication, problem-solving and visual immediacy) to replicate environments and scenarios, and practice skills.

Immersive learning represents a shift to a 'blended approach' to learning which encourages learners to interact with other students, instructors, and with content through thoughtful integration of both online and face-to-face environments.

This technology includes:

- **Virtual Reality (VR):** Creates an artificial environment, presented in such a way that the user accepts it as realistic – depending on the hardware and software involved. VR also includes 'hybrid immersive' which overlays a virtual environment onto a real life one to enable users to walk through and physically interact with scenarios.

- **Augmented Reality (AR):** A way of viewing a real object or scene that is augmented with immersive inputs including video, sound or graphics. Applications include overlaying data or contextual information on to the real world.

BENEFITS OF IMMERSIVE LEARNING AND KEY OPPORTUNITIES

"We can help with key problems, like getting a construction trainee on site. This is hard to organise in real life, so we can provide an opportunity to immerse learners in that environment without them physically needing to go there."

Jon Rashid, 3D Development Manager, Gaia Technology

Benefits of immersive learning include:

- **Enhance construction industry's appeal:** For some young people consulted in this research, construction was seen as a predominately dirty, low-paid, manual occupation, lacking opportunities to learn through state-of-the-art technology. Using technology for recruitment purposes can provide better insight into what construction is really like. Adopting it in training can also improve the current image of the industry by showcasing it to be future-focused. This is important to a new generation who have been brought up using gaming and virtual environments

- **Collaboration and problem solving skills:** Augmented reality environments allow new learners to experiment with and openly discuss what they are being taught. Users can practice solving problems to showcase their competencies. For example, they can simulate, across various teams and while ensuring health and safety, the building of an urban tower

- **Safety:** Instead of using videos and slides to illustrate safety risks, immersive learning can place a learner in a scenario such as working at height and ask them to look out for potential problems. While immersive learning cannot directly replicate all the hazards inherent in a construction environment, it can provide a safe opportunity to experience riskier tools and environments. Traditional training methods – such as desk-based learning or even small construction sites – are unable to immerse learners in environments the way these technologies can

- **Produce 'work-ready' employees:** This research found that applying immersive technology to a training context could ensure learners can develop the practical skills they need in work that may not otherwise be available through traditional methods. This helps make them 'work-ready' and far more attractive to potential employers

- **Better assessments through tracking data:** Immersive technology can track and capture a learner's progress, based on how they interact with tools and deal with situations. This leads to better assessments of student performance and more targeted support

- **Scalable:** The cost of immersive learning hardware is reducing and will become more affordable in time. Hardware can be more flexible and cost effective than traditional, classroom-based learning because the headsets and mobile devices can be used outside classrooms and without a set number of trainers

- **Cost effective tools:** Immersive learning can mitigate the need to solely practice on expensive tools and materials. Learners can practice the skills and competencies required to carry out tasks virtually before moving on to the real equipment. Trainers can also focus their attention on the most specific, high cost or hazardous real world training. For employers, it could also mean giving their employees the opportunity to practice new skills and competencies onsite without having to spend time away from site. Within each of these scenarios costs could be saved

CHALLENGES AND CONSIDERATIONS

While immersive learning represents an exciting opportunity, there are several challenges and considerations to be met. Challenges include addressing fragmented and inconsistent training and ensuring there is a 'level playing field' in the quality of immersive learning offered to learners across the UK.

Technological challenges and considerations

- **No current standards within tech:** There are currently no systems of accreditation or standards around the use of this tech

- **Early days for content development:** Content creation is still in its relative infancy, with varying degrees of quality and capabilities (e.g. ability to monitor and track learning progression)

- **Rapid pace of change:** This technology is being developed rapidly – which means that while applications are improving, technology can become quickly outdated

- **Variable set-up costs:** Costs can be variable depending on the tools and technology. Providers therefore need to carefully consider use and options available before purchasing

- **Unknown physical impact:** Some users have suggested that prolonged periods of use may cause disorientation and nausea – however, there is currently little evidence on the physical impact

Implementation challenges and considerations

- **Lack of understanding of what immersive technology and learning is:** There is limited understanding about what this technology is, what it can do and what it can achieve

- **Unclear benefits to investment:** Among non-users, there is uncertainty of the benefit or return on investment or how it would impact positively on educational targets, resource pressures and outcomes

- **Uncertainty over content development/application:** The industry currently lacks the internal technological and software development capabilities to introduce this technology in an effective and sustainable way

- **Unsustainable applications and duplication of effort:** Given that there are no common standards, there is a risk of unsustainable and fragmented use and application across the industry

- **Limitation of current training environments:** Some providers are limited by poor mobile technology (such as out of date devices or poor WiFi connections), while others struggle to attract instructors with the skills to train future workers using new and emerging digital technology

REPORT'S RECOMMENDATIONS

💬

"The industry requires collaboration and leadership to ensure this approach to training is introduced in the most effective and sustainable way possible."

Ben Lever, CITB Future Skills and Innovation Lead

There are a number of practical steps industry, training providers and government can take to encourage the application of immersive learning to deliver the benefits identified in this research.

The industry requires collaboration and leadership to ensure immersive learning is introduced in the most effective and sustainable way possible, fully influencing careers, standards and qualifications, and training and development.

In particular, there is a need to:

- **Inspire adoption** through showcasing examples of best use
- **Develop and share best practice** by supporting knowledge sharing and collaboration with sectors such as gaming and considering how standardised approaches can be developed
- **Incentivise uptake** by considering policy and funding levers

In addressing these needs, CITB proposes to take the following actions, in partnership with key stakeholders:

Promote and inspire:

- In partnership with industry, promote immersive learning tools and best practice via existing channels with employers, training providers and new entrants including via Go Construct, Construction Ambassadors, schools and careers events and industry-wide conferences
- Work with training providers and forums such as the Association of Colleges, British Association of Construction Heads and the Association of Employment and Learning Providers to identify and promote case studies of benefits and challenges
- Work with government and industry, particularly in conjunction with the Construction Leadership Council, to promote the adoption of immersive learning to achieve the aims of a Sector Deal for construction, along with the wider modernisation agenda

Support collaboration and sharing of best practice:

- Commission a number of immersive learning solutions, based on the success factors highlighted in this report – which define and showcase best practice to support wider industry adoption. These solutions, underpinned by CITB funding, will specifically seek to:
  - Build capability and capacity among employers and training providers to harness the opportunities of immersive learning for the workforce
  - Coordinate development and sharing of best practice and reusable assets across the sector
  - Empower employers as leaders and proponents of the tech, encouraging providers to invest
  - Demonstrate the value of collaborations between employers, providers and experts from other sectors such as gaming
  - Ensure projects monitor and record key outcome measures such as cost-effectiveness, skills development and recruitment to support the business case for wider industry

Further investigation:

- Use findings from funded commissions to assess the need and ability to establish formal standards on the use of immersive technology in construction

In addition, the following recommendations for employers and government can support the development and application of this technology:

For employers:

- Work more closely with training providers to develop immersive solutions to key issues such as the cost/value of training, and recruitment and retention of staff

- Explore opportunities for taking the hardware and visualisation software developed for specific projects, including BIM objects, and applying it to training contexts, thereby supporting curricula for apprentices and Continual Professional Development

For government:

- Work with industry, CITB and training institutions to support wider industry use of immersive technology via investment in initiatives such as Institutes of Technology, Construction Scotland Innovation Centre and Construction Wales Innovation Centre

- Building on the best-practice outcomes from the CITB commission, establish a working group to advise industry on standards and future developments in technology

- Establish a system of accreditation for educators to ensure there is a consistency of standards within the curriculum

- Undertake an inquiry into any potential health effects this technology could have with prolonged use and issue relevant guidance

BACKGROUND TO THE REPORT

The objective of this research is to provide CITB with an understanding of the potential role and enablers of immersive learning in construction training. The insight will provide recommendations where action should be taken to ensure that the industry has access to high quality, value for money, fit for purpose training.

To realise immersive learning's potential, a number of challenges must be addressed. These include the need to improve understanding amongst employers of what immersive learning is, increase expertise and avoid fragmented development.

AN EVOLUTION OF VIRTUAL AND AUGMENTED REALITY TECHNOLOGIES

1860

First elements of virtual reality appeared. French avant-garde playwright Antonin Artaud took the view that illusion was not distinct from reality, advocating that spectators at a play should suspend disbelief and regard the drama on stage as reality

1935

The first references to the more modern concept of virtual reality came from science fiction. Stanley G. Weinbaum's 1935 short story 'Pygmalion's Spectacles' describes a goggle-based virtual reality system with holographic recording of fictional experiences, including smell and touch

1950

Morton Heilig wrote in the 1950s of an 'Experience Theatre' that could encompass all the senses in an effective manner, thus drawing the viewer into the onscreen activity

1962

Morton Heilig built a prototype of his vision dubbed the Sensorama, along with five short films to be displayed in it while engaging multiple senses (sight, sound, smell, and touch)

1978

MIT created the Aspen Movie map, a virtual simulator

1980

'Virtual Reality' was popularized by Jaron Lanier, one of the modern pioneers of the field. Lanier had founded the company VPL Research in 1985. VPL Research has developed several VR devices like the Data Glove, the Eye Phone, and the Audio Sphere

The VR industry mainly provided VR devices for medical, flight simulation, automobile industry design, and military training purposes from 1970 to 1990
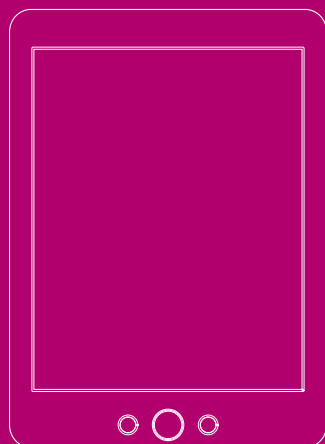
1991

In 1991, Carolina Cruz-Neira, Daniel J. Sandin and Thomas A. DeFanti from the Electronic Visualization Laboratory created the first cubic immersive room, The Cave

2010

Palmer Luckey designed the first prototype of the Oculus Rift

2013

Google Glass release – first commercial AR headset
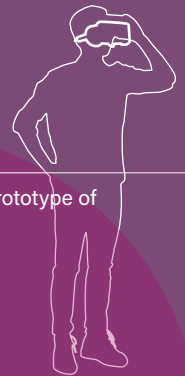
2014

Facebook purchased Oculus VR for $2 billion

Sony announced Project Morpheus (it's code name for PlayStation VR)

Google announces Cardboard, a do-it-yourself stereoscopic viewer for smartphones

2015

HTC and Valve Corporation announced the virtual reality headset HTC Vive and controllers

2016

At least 230 companies developing VR-related products – Google, Apple, Amazon, Microsoft, Sony, Samsung, Facebook

Pokémon go is released – first successful commercial use of AR to be used on mass

2017

AR becoming more of a reality through the use of smartphones and headsets such as the Microsoft hololens

Apple iPhone 8 – smartphones starting to push AR tech in big ways

2025

Commonplace in commercial and personal use, led by developments in AI and 'smart' assets – fundamentally changing the boundaries between physical and digital worlds

A shift from wearables to implantables

BACKGROUND AND METHODOLOGY

The purpose of the research

Immersive learning, through examples across industry, has shown it has a potential to become a revolutionary development in the delivery of effective and efficient training. The objective of this research is to provide CITB with an understanding of the potential role and enablers of immersive learning in construction training. The insight will provide recommendations where action should be taken to ensure that the industry has access to high quality, value for money, fit-for-purpose, training.

Specific research objectives include:

- To understand immersive learning's potential role within the construction industry

- To explore the forms of immersive learning currently in operation and how these could serve different roles within the industry

- To understand the awareness of and reaction to these technologies by different sectors of the industry – including where barriers exist and why

- Provide clear recommendations on where to encourage application and how to overcome or mitigate current challenges and considerations – both structural and in relation to the technology itself

METHODOLOGY

Approach

The research method for this project was qualitative and multi-phased and consisted of:

- 36 in-depth interviews with stakeholders across the industry to explore their current understanding of immersive learning/technology, how and where it could be applied and potential barriers to understanding. More specifically this included key representatives from:

  - 6 construction employers

  - 7 trade associations and federations

  - 10 training delivery bodies

  - 6 experts and thought leaders within construction

  - 4 technology companies

  - 3 experts from similar industries adopting immersive learning programmes

- 10 nationwide case study visits to sites using immersive technology in different capacities to understand in greater detail how, where and why they have been applying immersive learning – including barriers to implementation, both technological, structural and cultural

Across both interviews and case study visits, researchers recorded specific opinions and perspectives on the technology and approach to learning, as well as wider context about industry challenges. This included how and why training may not be currently meeting specific skills needs, areas of tension within the industry and potential opportunities and barriers to future innovation. While some of these were explicitly articulated, in other instances they were observed during the case study visits themselves.

Despite best efforts, the overall number of employers who took part in this research was relatively low. It was clear that employers of all sizes were either reluctant to discuss unfamiliar concepts or did not, in some cases, perceive training to be in their area of expertise or direct interest. While this is understandable, particularly in this emerging area of technology, it highlights the often cited disconnect between training provision and employment more generally (further discussed in the main report). Despite this, this research included the viewpoints of several federations and other stakeholders. Given that these federations often represent and collaborate with employers, a broader employer viewpoint was captured.

This research highlights important opportunities for future exploration, which would not only support the findings within this research but would also support CITB to tackle other challenges. These could include conducting an impact evaluation of the return of investment for immersive learning and investigating best practice including any health and safety considerations, to inform standards for use.

IMMERSIVE LEARNING

What and why?

WHAT IS IMMERSIVE LEARNING?

"Other Governments are already doing this. Currently, UAE has a poor record of health and safety on construction sites and illiteracy of the workforce – both in terms of UAE citizens and workers who are coming from abroad. The UAE government is beginning to look into developing VR training for improving health and safety on site. There is the potential that this will be mandatory, you will not get a visa without this kind of training."

Technology Developer

"Everything is or will be possible but there is currently a lack of understanding and imagination of what the technology can do. What technology companies are not saying is that immersive technology should replace training, instead it should help reinforce the key messages and skills they are trying to communicate."

Technology Developer

Immersive technologies

Immersive technology has grown in popularity and status over the last ten years – especially since companies such as HTC, Oculus, PlayStation and Google have brought (mainly VR products) into mainstream society. Over recent years, the growing accessibility of these technologies is converging with the explosion in data and digitisation of work, meaning that opportunities for use have grown. As such, the initial buzz has turned into real-value adding applications that businesses are investing into heavily. Educators too have begun to recognise that these technologies could be of benefit to training and development – enhancing traditional teaching methods and pushing e-learning.

An immersive learning environment allows students to become fully involved in an interactive, digital environment. It is experienced via computing hardware with a peripheral display unit, such as a computer monitor or headset, relevant software (built from the ground up or through customising existing software) and supplementary components, such as an accelerometer, gyroscope, laser tracking systems and handsets. Immersive technologies offer varying levels of interactivity, supervision and systems of assessment. This means that trainees can learn the basics of operating tower cranes on busy buildings sites; scale the highest wind turbines to perform complex maintenance procedures or visualise the detailed build stages of a skyscraper in 3D. All without leaving the classroom.

This research in particular explored the use of augmented reality (AR) and virtual reality (VR) and how also a process of games-based learning could be implemented within these immersive technologies. This process involves using appropriate game elements – such as collaboration, communication, problem solving and visual immediacy to enrich the learning experience While the benefits these technologies could bring to learning are already evident, there are still key differences between virtual and augmented reality – particularly in terms of the maturity of the hardware and software available and their relative affordability. AR, for instance, is still not widely available and a seamless integration and overlay of data on to real world environments is still evolving. Despite this, as with all emerging technology, it will only be a matter of time before the technology becomes more widely available, usable and could be of key importance for educational developments across the globe. For instance, governments from China and UAE have already begun to explore how to apply immersive technology into construction training – both to improve quality, efficiency and the overall safety of its workers.

AUGMENTED REALITY (AR)
Overlaying information on to the real world

VIRTUAL REALITY (VR)
Immersion into a virtual world

	AUGMENTED REALITY (AR)	VIRTUAL REALITY (VR)
ABOUT THE TECHNOLOGY	• A way of viewing a real object or scene that is augmented with immersive inputs including video, sound or graphics • Applications include overlaying data/ contextual information onto the real world • Examples include visualising 3D building plans in-situ and visualising utilities/ connections in existing buildings	• Creates an artificial environment, presented to the user in such a way that the user accepts it as realistic; the level of immersion depends on the hardware and software involved • VR can also include 'hybrid immersive' which overlays a virtual environment onto a real life one to enable users to walk through and physically interact with scenarios
TOOLS	• Headsets: Microsoft Hololens, Google Glass/Tango • Smartphones • Tablets • Handsets • Tracking devices	• CAVE environments (computer augmented virtual environments) • Headsets – PlayStation, HTC, Oculus Rift • Smartphones – Google cardboard, Samsung gear360 • Simulators • Handsets • Tracking devices
PROS	• Ability to overlay information on to a real world environment – e.g. by showing blueprints on real construction projects/ sites • More collaborative as they don't involve removing the user out of current situation • AR tools/headsets can be lighter and easier to use	• Enables complex or dangerous procedures to be executed in a photo realistic environment with a range of user interaction • Far more affordable and developed currently than AR
CONS	• High initial set up costs • Current very limited uses due to the relative infancy of the technology	• Not a truly immersive experience – can only give a limited idea of the surrounding environment • VR headsets can involve shutting users off so may not be as collaborative – however, this can be mitigated by multi-user applications and ability to speak with users
EXAMPLES	• General Motors: Using Google Glass to train factory workers in real time and provide immediate feedback, with users seeing the correct techniques in their Google glass as they perform tasks	• US Military: Using VR simulators to teach soldiers how to operate a plan or vehicle and handle emergency situations. Simulators provide instant and constant feedback to help soldiers adjust movements in real time

Benefits of immersive technologies

Immersive learning in construction could in the first instance help to deliver both general and specialist training in a more cost efficient and effective way; helping to overcome some of the perennial issues of limited coverage and poor quality training. It also reflects the shift to more digital, interactive and data-led industry where using simulated models and environments will become even more relevant as businesses adopt digital processes in their everyday work e.g. the application of BIM Level 2 and 3.

Example benefits include:

- **Collaboration and communication skills:** Through processes of data visualisation, immersive storytelling, multi-party gaming, virtual avatars and speakers in headsets, users are able to confront and talk through construction challenges at a time and pace to suit a learner's development

- With AR environments, the ability to see multiple types of content, interact with content/information, and overlay data, audio and video streams on to real world-environments, improves the ability for new learners to openly discuss and talk through what they are being taught

- **Problem solving skills:** Immersive learning environments offer a way in which to visualise and manipulate data through interactive and collaborative spaces. Because of this, and through recent improvements in graphics and motion tracking, users can practice solving problems, many times, until they can showcase their competencies (as monitored through real-time data) e.g. simulate the building of a tower in a restricted urban environment and how to optimise sequencing across various teams and ensure health and safety

- **Safety:** Where new learners are unable to practice skills on real life construction sites, or using potentially dangerous tools. Which is often the case in construction today (see 'a safe place to fail') immersive learning provides them the opportunity to do so in a safe, but realistic, environment/using virtual tools which are designed to feel and look the same as the real thing. In turn, through processes such as building muscle memory, learners are able to safely and competently manage tools and environments without compromising their safety in the first instance

- **Cost-effective:** Unlike when using real materials and in time-restricted settings, this technology allows learners to practice skills infinite times with no penalty of wasted materials or costs associated with travelling to training environments

- **Scalable:** The cost of hardware is reducing and overtime they will only become more affordable. This makes them far more scalable, flexible and therefore more cost effective than traditional, classroom based learning alone. This is because the use of headsets is unconfined to classrooms and a set number of trainers

- **Can enhance appeal of an industry:** Using the technology for recruitment purposes (e.g. at careers fairs) can provide a better insight of what construction is. It can also change the current image of the industry for the better by showcasing the industry to be future-focused and more relevant. This is especially important to an entire generation who have been brought up used to gaming and virtual environments

- **Tracking data:** Physical trainers can only observe so much from what someone is doing in training – immersive technology on the other hand has the ability to track how a learner is progressing, based on how they interact with tools/deal with situations. This leads to better assessments of student performance and more targeted support

"There is currently no full suite of hardware and software for companies to buy – it's very ad-hoc at the moment. Also, the costs can be quite high in the first instance. But you need to think of it like this. You can have a PowerPoint costing £150 per person, and you can only really deliver that well once. Whereas VR programmes come in at about £60 per person. This is a long-term saving. I would encourage all educators to start thinking about cost first. What are they spending, and what could they save?"

Technology Developer

Technological considerations

As with all new and emerging technologies the maximum impact is often achieved in the long-term. There are a number of technological considerations to take note of, including:

- **No current standards within tech:** There are currently no systems of accreditation or standards around the use of this tech – both in and outside of education. This means that there are challenges around assuring that the technology is introduced into learning environments in a sustainable and effective way

- **Early days for content development:** Content creation is still in its relative infancy, with varying degrees of quality and capabilities. Given this, it might take some time before both high-quality content is matched with the ability to monitor and track learner's progression. Training providers will need to be mindful that immersive applications may not be the 'finished package' as of yet

- **Rapid pace of change:** This technology is being developed rapidly – which means that while applications are improving, it also means that technology can become quickly outdated/requiring updating. This means that the technology needs to be monitored and providers are aware that there may be upfront and ongoing costs associated with its application

- **Variable set-up costs:** Costs can be variable depending on the tools and technology – e.g. while headsets are becoming more affordable, a cave automatic virtual environment is still expensive and requires greater digital infrastructure. Despite this, technological developments and cheaper cameras have already lowered the entry point. This means providers will need to carefully assess what would be feasible for their learning environment before investing into technology which may not have as greater impact

- **Physical impact:** A small number of users have suggested that prolonged periods of use of virtual reality may cause disorientation and nausea – specifically those who are being immersed to work at height. However, there is currently little evidence of adverse physical impact and where wit has been noted it is after hours of uninterrupted use

TRAINING A FUTURE WORKFORCE

The role for immersive learning

INTRODUCTION

Providing training which meets the current and future needs of the industry is a task which requires an approach to learning which is both interactive and inspirational. A key component of this is to ensure that learners can interact with other students, instructors, and with content through effective integration of online and face-to-face environments. Currently, this approach to training is not commonplace within construction. Some providers are fully embracing digital methods and blended learning approaches and others are struggling to access the most basic of digital tools. The reasons for this are numerous – much of which are related to funding, access to digital infrastructure and the ability of educational leaders to build effective cross-sector collaborations.

This inconsistency in use of digital methods clearly reflects a disparity in quality and consistency within the industry, which undoubtedly impacts on learners, employers and the industry as a whole. For instance, some learners are not equipped or inspired to enter the industry at all and employers may not trust that future workers will be willing and able to display the competencies to enter into their business. As such, the industry suffers from not having the skilled or available workers to support current and future skills needs. While these issues cannot be entirely solved by the application of immersive technology in training environments, this research has recognised several training opportunities and challenges which could be supported through the appropriate application of immersive learning.

KEY AREAS OF APPLICATION

There are many individual areas of opportunity where immersive technology could be applied in a construction training context. Below are examples of the types of training challenge, sector and skills development which could be supported through immersive learning. All of those included are areas of application which have been observed through case study visits or discussed via in-depth interviews.

CHALLENGE	SECTORS	EXAMPLE IMMERSIVE LEARNING APPLICATIONS
POTENTIALLY DANGEROUS	Equipment operators Masonry Iron workers Electricians Roofers	• Simulators to teach operators on how to handle dangerous machinery (also while dealing with multiple hazards) • CAVE systems to immerse learners in construction environment and set targets for spotting hazards (game-based) • Using direct replicas of construction tools in VR to practice skills before progressing on to actual equipment – using tracking, sensors and control technology to ensure the safety of workers
REQUIRES THE DEVELOPMENT OF TECHNICAL SKILLS	Equipment operators Electricians Plumbers/pipefitters Insulation workers Inspectors/ safety worker	• Using direct replicas of tools to practice skills in VR until competent to progress – these could include tracking, sensors and control technology to ensure skills are executed as accurately as possible • Overlaying on to real wall (using AR) where insulation and piping should be laid • Vehicle simulators to ensure workers can operate machinery
POTENTIALLY COSTLY (RESOURCE/SPACE/ EQUIPMENT/MATERIALS)	Equipment operators Masonry Electricians Plumbers/pipefitters	• Using direct replicas of tools to practice skills in VR until competent to progress – these could include tracking, sensors and control technology to ensure skills are executed as accurately as possible • VR programmes to teach core competencies to reduce need for hands-on instructors, allowing more instructors to be involved in hands on delivery
REQUIRES UPDATING	Site managers Operators	• VR headset based health and safety training to update workers on site about procedures and protocols (new and existing)

Improving current training delivery

The key areas where immersive learning could support the delivery on training and the challenges they would help mitigate are outlined below. This includes direct benefits to training and examples of use observed and recorded as part of this research.

IMPROVING QUALITY AND CONSISTENCY

"We find it hard to get employers to engage with us and our students. We invite them to a coffee morning but they generally don't show up. On top of this we only have PowerPoint and a few tools for kids to practice on. How can we get young people to want to be in this industry and understand what it's about if we can't deliver realistic training?"

FE College Tutor

"The kids that are doing well academically tend to be more interested in engineering. I think they see more opportunity for growth and an ability to use this kind of tech. As a college, we are also more successful in engaging these engineering firms, so the routes for kids are more firmly in place. We have tried engagement exercises with construction firms but the take up isn't as high."

Business Development Manager, UTC

! The challenge:

The quality and offer of all training is fragmented and changeable – both in terms of the digital infrastructure in place and the outcomes of its learners. Some Further Education (FE) providers, for instance, spoke of their frustration at not being able to offer up to date, realistic and digitally enabled training. The reason for this was cited as being wedded to out-of-date curricula, limited access to funding, poor investment in digital infrastructure and being unable to forge the working partnerships with the sectors and employers who could support this offer.

The impact of these issues on learners was clear. Some training providers recognised that they were unable to provide the inspiration or realistic experience of working within the industry and were conscious that as educational providers they were struggling to attract enterprising students to their programmes. The result of this is not insignificant. For instance, some had recorded that after finishing their construction programmes, students were not entering in to the industry at all. Instead they had found local, zero hours, paid work. Alternatively, some educational providers which offered several apprenticeships recognised that their students were looking to other industries as an alternative to construction. These industries, such as engineering and automotive, were seen to be able to offer them the opportunity to learn with and through technology, be part of and support the growth of a future-facing industry and be given well-paid work experience.

Despite this, it was clear that some training providers could and did provide the training which not only inspired learners but gave them a realistic experience of the construction industry. In these cases outcomes for learners were much more positive, with higher numbers entering the industry, having secured apprenticeships and contracts with employers. From an employer perspective, it was clear that these students were more able and ready to work. While there are several reasons for this – such as these providers being managed by entrepreneurial leaders who could build successful partnerships and collaborations with employers and with other sectors who could support their growth – it was also clear that within each of them, digital technology, including immersive technology, was at the forefront of their approach to learning.

The role for immersive learning:

While the issues of training quality and student outcomes will clearly not be resolved by the application of immersive technology alone, our case studies show how creating a blended learning environment (bringing together digital technology with face-to-face training) has achieved significant benefits. For these providers, immersive technology could achieve the following:

- **Enrich learning experience and outcomes:** Gamifying tasks in VR, such as welding, to ensure learners understand the processes involved in developing skills and competencies. By making it a game, ensuring learners have reached a certain level before progressing on to 'real tools' only encourages greater engagement as they naturally want to 'get to the next level.' In turn this enhances interest in what could be traditionally seen as a 'mundane' job

- **Ensure students have some experience of industry and are more work-ready:** Using headsets to immerse students in scenarios/environments, such as what it is like to work at height, means they can 'try out' jobs in a light-touch way before being allowed into real world environments

- **Encourage collaboration and problem solving skills:** Employers putting 'industry challenges' to groups of learners to be solved using immersive technology ensures that employers have been involved in training delivery and learners have been able to practice group-based problem-solving and in environments which are as close to the 'real thing' as possible

- **More accurate competency assessments:** Showing how well in real-time data, a learner is able to carry out tasks, such as operate machinery, ensures employers are able to confidently assess how much of a risk an employee may be. This in turn could create 'standards' on what level of competency a learner must display before progressing onsite (as proposed by UAE Government)

- **Freeing up trainer capacity:** Having learners practice skills using immersive technology has been shown to free up trainer capacity, as it means that trainers can focus solely on skills development on real life tools/scenarios. By being able to pay greater attention to these learners means the quality of training is ultimately improved, as shown by the plant operatives at CITB

DUDLEY COLLEGE

Dudley College, a well-established provider of construction qualifications, from pre-foundation level to Apprenticeships and Higher Education, have recognised that the industry is suffering due to a lack of appeal and an ability to deliver higher level skills and support new building techniques. Acknowledging the key part education must play in increasing engagement and supporting innovation – they are in the process of developing a new training suite, dedicated to emerging skills within industry. This suite will involve using immersive technology as a training tool – for both the development of specific skills and for learner's interaction with their learning environment more generally.

Applications of immersive technology

- Using virtual reality to teach students how to interact with high-cost tools/materials before progressing on to real thing

- Using augmented reality to show learners the processes that are involved in construction – especially within their own learning environment

Success factors

- Recognising the need to provide training for both current and future skills for industry

- Developing a business case for using technology in training – such as how it saves trainer resource

- Developing working partnerships with technology companies

- Encouraging engagement and collaboration from employers through opportunities for their involvement in skills development

"We have been using VR for years but we are at a moment now where we cannot separate immersive technology from skills development more generally. It's about creating that mindset within future generations and encouraging people to want to be involved. Not only will we use immersive technology to teach specific skills, but learners will all be encouraged to download a QR code which they will be able to hold up to any wall in the building and see the infrastructure that goes behind it."

Neil Thomas, Vice Principal

GAIA TECHNOLOGIES IN COLLABORATION WITH LIVERPOOL JOHN MOORES UNIVERSITY AND COLEG LLANDRILLO CYMRU

Gaia Technologies provide software solutions predominantly for schools, colleges and universities across the education spectrum. They support these educational institutions to develop VR content which can engage learners in content and teach them valuable skills. For instance, they have recently provided Liverpool John Moores University and Coleg Llandrillo Cymru with a mocked-up construction site, where students can immerse themselves, interact with the surroundings and experience different modules. These include, health and safety, construction techniques and how to interact with different tools. While specific outcomes have not yet been monitored, they have received early indication that engagement of learners has increased, as well as overall interest in finding employment within construction.

Example applications of immersive technology

- Providing immersive construction environments for learners to interact with and learn about working in construction (through VR). These have been developed with, instead of replacing, current curriculum

Success factors

- Starting with a business case – helping to solve problems in education by providing engaging content

- Producing models to the highest quality and have 'lowest spec' attitude of what device this must then work on

- Purposefully producing content to enhance/complement courses in education – as opposed to replacing them

"One of the questions we get asked all the time by teachers is 'does what you produce match my curriculum?' Our answer is always 'no – but we can help to enhance your teaching – not replace it.' We can help with key problems, like getting a construction trainee on site. This is hard to organise in real life, so we can provide an opportunity to immerse learners in that environment without them physically needed to go there."

Jon Rashid,
3D Development Manager

LONDON DESIGN AND ENGINEERING

London College of Design and Engineering UTC is a new STEM (Science Technology, Engineering and Maths) college which opened its doors in September 2016. Since opening, the college has established strong links with industry, including Costain, Balfour Beatty and Skanska, coupled with a number of technology companies, such as Oculus and Fujitsu. As such, they have been using Oculus rift headsets, robotics labs as well as Autodesk and adobe suites as key training delivery tools. The college recognise that the way to empower students to learn is to create a 'real world' education setting where teachers view themselves as facilitators. As part of this, immersive technology is viewed as part of a continuum of learning, whereby they carry out tasks such as testing student's 3D modelling ability through Oculus Rift headsets.

Example applications of immersive technology

- 3D modelling of assets and testing in Oculus Rift headsets

Success factors

- Recognising that immersive technology is a key educational tool – one which students can learn both with, and through

- Recognising that asking students to create content which can be shared and seen by a wider community – including employers – instils in them a sense of responsibility towards and ownership of their learning

- Identifying and building relationships with technology providers and building in house capabilities

"One of the biggest barriers we have is that we are training people for jobs that don't exist yet. We are at the edge of disruptive education. Yet we firmly believe that you need to train students not just for now but for their future."

James Culley, 3D Visualisation and Animation Course Tutor

A COST-EFFECTIVE TOOL

"Employers often complain about the high costs associated with training apprentices. Not only the time to make sure they are OK, but also the mistakes they might make on site. If you are small these mistakes can be costly. Especially in an industry which is structured around a supply chain, with the smaller SMEs often waiting for late payment of invoices."

Trade Association Representative

"We call them the guys who have come off the tools. They are now in training. We have a few father and son combinations who travel up and down the country training people to operate machinery. The older guys are quite close to retirement age and can be few and far between."

Trade Association Skills Manager

! The challenge:

Training in construction is not cheap. Both in terms of paying for trainers, the space and equipment required and in some cases the costs to employers to take their workers offsite to learn new skills. These high costs ultimately impact on the ability to provide up-to-date and adequate training and in turn impact on the value employers attribute to offsite training.

Unlike other industries, many sectors within construction require large spaces and expensive equipment to train its workers, such as training plant operators. Practices, such as welding, generate large amounts of material waste as learners practice through trial and error. Onsite training also carries risks for employers, particularly if new workers or apprentices make mistakes on a live project.

In addition to these physical resources, the cost of paying for trainers and instructors is not insignificant. Especially when, as currently seen in construction, there is a shortage of trainers, particularly those familiar with more modern methods.

Finally, despite some receiving financial support to access training, many stakeholders across this research recognised that for some employers – especially those of smaller companies – having workers onsite and ready to work is far more valuable than paying for their time to train offsite. While this is a by product of the small margins and cyclical working inherent in the industry, it undoubtedly has a direct impact on the quality of working, access to skilled workers and therefore the sustainability of the industry. For instance, if training is viewed as a high-cost, low-return, investment for employers, there will come a point where limited access to skilled workers will be an unavoidable reality for employers of all sizes. This is especially problematic within today's climate of uncertainty surrounding Brexit and an ageing workforce.
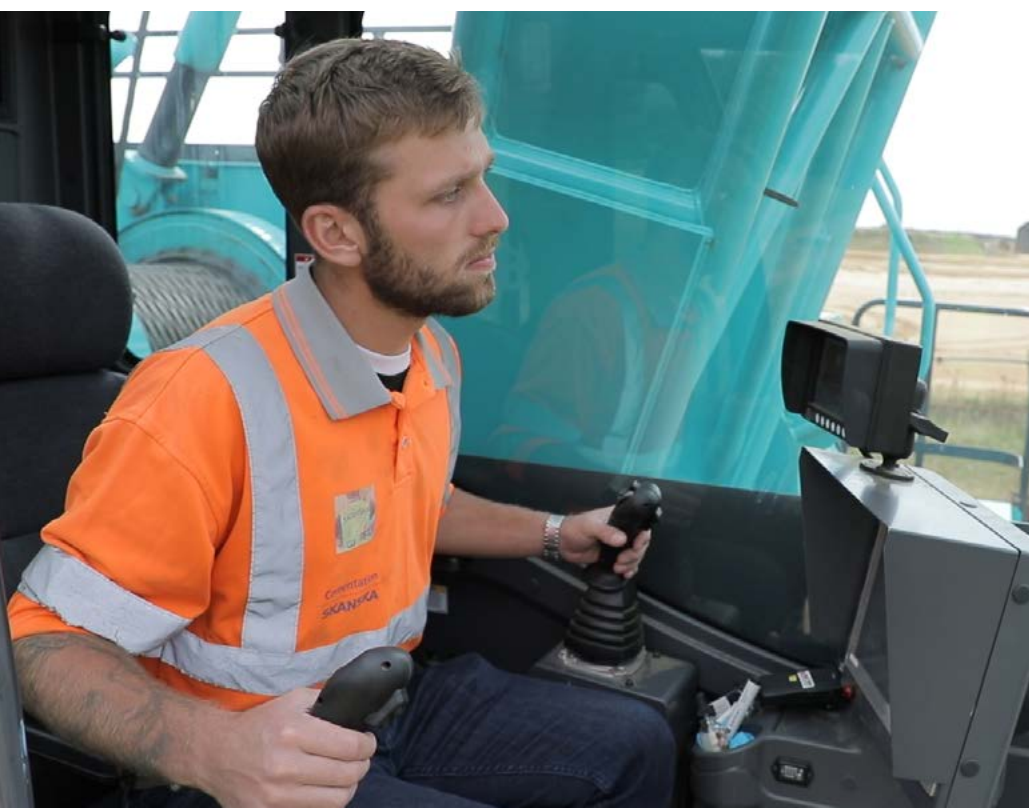
"It's not that employers don't think training is valuable, they do, it's just we are operating on small margins which means often other things need to take priority. We had a turnover of 1.3 billion last year, but the profit before tax was only 15 million. That's a huge difference."

Large construction employer

The role for immersive learning:

Making training more cost-effective and raising its value among employers are big challenges that training technology alone will not solve. However, applying immersive learning technologies would not only help make training provision more cost-effective, but could ultimately form part of a general shift to immersive training within the industry. For instance, by blending face-to-face teaching with digital tools – thereby supporting resource pressures and training multiple learners at once.

- **Reduces waste – practicing and showing competencies:** Practicing and showing competencies in immersive technology has been shown to reduce the waste of practicing on real life materials (such as in stonemasonry/welding) because learners are able to practice holding and controlling virtual tools first. This in turn is believed to have an impact of wastage/mistakes made by new apprentices onsite

- **Reduces need for employees to leave sites for long periods of time:** Providers are beginning to explore the cost-saving implications of developing programmes which don't require learners to leave construction sites – which can cost employers up to £3000 per learner. Hire Association Europe and their development of a VR health and safety programme (see case study) have shown that the cost-saving implications of immersive learning could be huge, given that thousands could be trained without physically having to leave a construction site

- **Reduces equipment expenses:** Some training equipment – such as cranes – are expensive to run and maintain. Especially when those using them may not be fully qualified in how to safely manage them. Immersive learning ensures that learners are able to maximise training time by learning core competencies, before progressing to the real-life equipment

- **Reduces equipment expenses:** As above, having learners practice skills using immersive technology has been shown to free up trainer capacity, as it means that trainers can act more as facilitators on immersive learning activities and allocate more time to skills development on real life tools/scenarios. This means a greater number of people can be trained overall at a lower unit cost – especially where real life tools are expensive and limited, such as cranes

IGLOO IN COLLABORATION WITH LANES PLC/THAMES WATER

After recognising a number of issues within the sewage industry – including high staff turnover, issues of workforce illiteracy and the cost of training staff members reaching thousands per person – Lanes PLC decided to ensure their training was as good as it could possibly be, through a number of initiatives. Lanes PLC introduced 'the Igloo System' – a 360% immersive experience to place the user/group into a scenario. Igloo, enabled them to see what a real life working environment would be like and the skills and competencies they would need to display, both as a single user and as a group. While not fully established, Lanes PLC have already begun to see early indications of higher retention rates of learners. Overtime they are also going to monitor how training using the Igloo impacts on the reductions of industry problems – such as a reduction in flooding rates.

Example applications of immersive learning

- Using 360 immersive projection environment (Igloo) to engage new recruits in different scenarios and solve problems as an individual and as a group

- Using real-life examples in a virtual environment – effectively bringing to life experiences at scale

Success factors

- Recognising the need to develop a business case and monitor outcomes for learner – including by tracking how problems within industry have been reduced/mitigated since the use of immersive learning

- Successful collaboration with technology company to ensure that content is developed to meet both training requirements and overall industry needs (such as attracting new talent, retention of workers and resource waste)

"All scenarios are different in real life – as trainers we can only teach so much. In the future, we are going to get veterans to tellus the hardest job they have encountered and how they solved them. We will then replicate and film these issues and get the veterans to deliver the training sessions in the igloo to new recruits. It's about bottling up real experience and passing it on. That's how you can properly engage learners."

Dean Hansford, Head of Logistics

READING UTC

Reading UTC are a technical college offering qualifications in engineering and construction. Having recognised a key opportunity in bringing students and employers together around shared problem solving, the college developed an immersive learning collaborative project. Engineering students were tasked with using Fujitsu wearable technology to address the challenges faced by the engineering and construction industry. Over a series of full day sessions with Fujitsu and an industry partner (which included: Peter Brett Associates (PBA), Thames Water, National Grid and AWE). Students wrote a point of concept and developed a solution to their chosen problem. These included, improving driver safety, the ability to work from height and saving the cost of maintenance. The winning group used augmented reality headsets to increase the accuracy of maintenance, digging, and repairs using a 3D underground rendering system. While focused mainly on engineering, Reading UTC recognised the key benefits for all learners and employers – namely that collaboration through immersive technology increases engagement from both sides.

Example applications of immersive learning

- Developed an immersive technology employer challenge, whereby students had to solve an industry problem through and with immersive technology (while receiving mentoring from an industry partner and Fujitsu)

Success factors

- Using business interests of employers to drive interest in immersive learning (e.g. finding solutions to problems, finding future employees and fulfilling social responsibilities)

- Recognises how collaborative partnership between education, employers and technology companies can improve outcomes of learners/increase interest in a sector

"This was a chance for industry partners to mentor – and be seen to be mentoring – students while actively promoting the future of their industry, in terms of technology and future skills. The kids themselves also had an opportunity to learn and solve problems with and through emerging technology.
This would be a great thing to do with construction firms."

Michael Halliday, Business Relations Manager

A SAFE PLACE TO FAIL

❗ The challenge:

Construction can, for some sectors, pose high health and safety risks – with many complex tools and processes required in its delivery. Some trainees are unable to enter real life construction environments or practice using certain tools in case of injury. This can present an issue in ensuring trainees are sufficiently competent in their job before entering employment.

While training environments do their best to showcase the hazards and risk inherent within construction, in many cases this is communicated verbally, by video or PowerPoint. While these are all valid teaching tools, they are unable to showcase the often numerous hazards you could experience, nor can they prepare a learner to use the equipment they would need in a safe way.

◫ The role for immersive learning:

While immersive learning cannot directly replicate all the hazards and risks inherent in a construction environment, it can provide an invaluable opportunity to experience potentially dangerous tools and environments within a safe space, as many times as needed to showcase the competencies required on site. This is a step beyond current training tools which are only able to communicate what hazards may exist and are not able to give trainees the opportunity to physically practice on tools.

- **Better H&S competency via immersion in 'higher-risk' environments:** Several providers are developing immersive experiences which involve identifying construction hazards onsite. Given that many are unable to access a real life construction environment, the ability to practice hazard identification in an immersive environment (where several activities are going on at once) is an important development from non-interactive learning tools. This is especially effective given that students could be put into a higher risk virtual environment to learn competencies that they otherwise wouldn't get to experience until later in their learner/employment pathway

- **Measuring capability:** One of the greatest benefits of immersive learning is recognised to be the growing ability to track learner's capabilities and progression. A number of training providers believe this could have the greatest impact on the overall safety of workers – given that standards could be set, based on accurately monitored tracking of how learners interact with tools

- **Freeing up trainer capacity:** Having learners practice skills using immersive technology first means less time is spent by tutors teaching all the basic competencies – freeing up the capacity for trainers to focus on higher-value training on the actual tools. By being able to pay greater attention to these learners means trainers are more able to assess a learner's safety consciousness, as shown by Laing O'Rourke recognising that trainees who had used the CITB simulators (see case study) were far more safety conscious and therefore employable

"There are universal training needs across the industry. Wouldn't it be easier if everyone knew, site to site, contractor to contractor that people had experienced the same training and knew how to use tools safely and efficiently. We believe that using VR we can provide a programme of training where employers wouldn't have to pay for workers to go offwvsite, but can learn about tools in an engaging and interactive environment. This doesn't mean they won't train using the real thing, but it means less time would be needed training on this equipment, therefore saving time and cost."

Richard Whiting,
Commercial Manager

HIRE ASSOCIATION EUROPE

Hire Association Europe (HAE) are the representative association for the hire sector – representing over 850 members, spread across 3,500 depots, and covering over 50,000 workers. Having recognised that the industry struggles to provide adequate training to its workers, the association has developed a VR training programme to ensure construction workers are engaging with health and safety regulations. Over time, HAE believe this will ensure workers are adequately trained to use expensive and potentially dangerous tools. In the longer-term plan they believe this could also provide a solution to trainer shortages and provide an opportunity for remote training and assessment.

Example applications of immersive learning

- Developed a VR training programme – complete with modules – to ensure workers have engaged with different health and safety regulations before progressing on to real tools

Success factors

- Recognises a universal problem (health and safety) prior to developing a tech solution
- Recognises the cost-saving implications for employers and trainers as a key benefit – therefore building an effective business case for the technology

CITB PLANT OPERATIONS

Part of the NCC (National Construction College), CITB opened its simulator facility in February 2017. This simulator is used to support trainees to practice crane manoeuvres and plant vehicle driving in a hyper realistic environment without the high costs and potentially dangerous scenarios of real world machine operating. In addition to this, the simulators provide data on learners use and progression, which can be used as an assessment tool in the future to create a detailed profile of learners and enable employers to select who may be ready and most appropriate for an operative job. Early feedback from Laing O'Rourke has shown they view these learners as more safety conscious and accurate than those who have not used this technology.

Example applications of immersive learning

- Using simulators and virtual reality to emulate crane lifting/plant vehicle manoeuvres and control

Success factors

- Recognising how using these technologies can not only improve industry standards but can reduce resource pressures on a limited pool of trainers
- Recognising the need to leverage skills from other sectors – including from software development
- Capturing outcomes of learners and impact on employability/employers

IMPROVING THE APPEAL OF CONSTRUCTION

❗ The challenge:

There has been much speculation as to why the industry may currently lack appeal. However, it was recognised by many during this research that much of this stems from how people enter the industry and their experience of learning. For instance, there was a sense that it is only young people who have struggled academically who are signposted to careers in construction. Those who are more academically able are deemed to be more appropriate for industries such as engineering, architecture or design – despite the huge crossover in competencies, skills and outputs of these industries. For some of the young people consulted as part of this research, construction was deemed to be a predominately dirty, low-paid, manual occupation which was lacking in opportunities to learn with and through technology, amongst forward-thinking and aspirational peers. This is despite the industry representing vastly different sectors and occupations and increasingly offering a range of opportunities geared towards different skillsets.

Throughout this research, it was clear that stakeholders recognised immersive technology could play a fundamental part in increasing the attractiveness of the industry to potential workers, providers and investors. This was deemed to be of paramount importance if it is to attract workers with the right attitude and skills to support the UK industry to compete with and benefit from innovations and developments happening elsewhere. This includes direct competitors and those within other industries – such as in manufacturing, engineering and automotive.

While the need for skilled manual workers remains, and indeed there is a shortage amongst some sectors, this does not mean the process of signposting, nor the experience of learning should be compromised. For instance, for the small number of future-focused training providers consulted in this research, one of the key ways to attract people into the industry was through promoting engagement with construction through technology. This included showcasing what it is like to be immersed onsite through VR headsets, through to offering the opportunity to 'try out' different occupations. For some, creating this kind of learning environment was a no brainer, given that over time many workers and businesses will need to be able to competently use and access digital technology – no matter if they are onsite or not.

⬛ The role for immersive learning:

Immersive technology in this case can form two important functions in the short and longer term. In the short term, utilising these technologies could engage people in what is available and possible within the industry (a 'way in'), while in the long term it could directly impact on the process of skills development and learning. This would not only equip the industry with people who understand digital technology, but overtime would showcase the industry to be actively invested in innovation.

- **Immersion/excitement:** One of the most universal applications of immersive technology is showcasing to potential recruits what working in construction could involve. This includes being able to show how dynamic and different the industry is to current perceptions (e.g. that it only involves manual labour and little room for innovation). Some providers are doing this from an early age, by showing primary school children through VR how exciting and future focused construction is

- **Creating a more advanced and dynamic industry:** Some providers are seeing immersive learning as a natural progression to a digitally enabled industry, which will increasingly rely on immersive tech for building processes. Familiarising trainees with these tools and interacting with digital models is therefore an important means to ensure that the industry is creating a more advanced, engaged and digitally-enabled workforce which is prepared for making best use of digital technology (e.g. BIM)

  There are early indicators that creating this more engaging learning environment in turn increases the satisfaction of trainees and overall retention rates of its learners (see Lanes case study)

- **Opportunities for employers:** As with providers, employers are now also being given new opportunities to showcase their businesses to future recruits. At the same time, it may encourage those who have been slower to adopt this technology to invest in order to recruit the best talent

CASE STUDY

HERIOT-WATT UNIVERSITY

Recognising the current skills shortage within industry and the current lack of active decision-making by young people into what different construction disciplines are actually about, Heriot-Watt University researchers have developed a series of VR games and experiences, such as working from height, to immerse learners into the industry, showcase potential opportunities and also practice specific skills. In addition to recognising the ways in which using VR attracts young people into the industry, they have also recognised the need to practice and monitor learner's progression – not only to improve skills but to showcase to learners and employers how safely and efficiently they are able to display construction competencies. Overtime, they believe this will improve the quality and safety of the industry more generally and will support the continued growth of a future-facing industry.

Example applications of immersive technology

- Immersive Hybrid Reality (iHR) systems to create mixed reality systems to enable college apprentices to perform actual tasks while being immersed within virtual but realistic construction site conditions (thereby improving trainee's perception and experience of industry)

- Virtual Reality Gaming Apps to show potential trainees what a career in construction could involve

Success factors
- Recognising the problem which needs to be resolved prior to creating the technological solution
- Collaborative working between Higher and Further Education – recognising where and how immersive learning could be applied in a real learning environment
- Bringing in skills from other sectors to ensure effective development of immersive learning programmes – such as by integrating academics and professionals from across construction, digital engineering and games-development
- Two iHR systems deployed in two colleges

ADVANCED MANUFACTURING RESEARCH CENTRE (AMRC)

Advanced Manufacturing Research Centre (AMRC – part of the University of Sheffield) supports manufacturers of any size to become more competitive by introducing advanced techniques, technologies and processes. Operating between several related industries, AMRC are keen to solve construction challenges – including waste associated with onsite installation by including augmented and virtual reality technologies into the development of solutions for industry. AMRC recognise that using these technologies for training could mitigate some immediate challenges, such shortening training time so trainees can get on to site quicker. They also cite many longer-term benefits, related to the development of solutions, such as developing a critical and 'visual mindset' in future construction workers, so to adequately prepare them for a digitally enabled and completive industry.

Example applications of immersive technology

- Augmented reality (in collaboration with Carbon Dynamic) to showcase where and how piping and insulation should be installed in a wall

Success factors

- Provides an aspirational and future-focused environment in which to learn
- Recognises the need to hire in employees with skillsets from other industries – such as software developers
- Recognising both the short and long-term benefits to using immersive technology – including how it represents an overall shift to a more digitally enabled industry
- Providing opportunities for collaboration with employers by enabling them to create their own immersive learning training delivery tools to be used by apprentices

"We shouldn't undersell the power of immersive technology. It's about training in a whole-space. Immersion bridges together communication and content in a way which will be completely necessary for the future of the industry. We can have conversations about apprentices, but now we need to have conversations about how we train these apprentices to be equipped in the right way to operate effectively in this space. We can't not train people using the same tools we would expect them to use."

Colin Sirett, Head of Research

CONSTRUCTION SCOTLAND INNOVATION CENTRE

Since 2014, Construction Scotland Innovation Centre have been linking together businesses, university experts and public sector providers including Scottish Enterprise and Scottish Development International to deliver change in construction. More specifically, the centre exists to support the industry to access skills and research and reduce the cost of duplicating efforts within the industry. In September 2017, the centre will also be launching a facility to enable Scotland's construction businesses to access state of the art production and prototyping equipment and technology. The building will also provide a range of collaboration and training facilities to allow organisations in the private, public and academic sectors to share knowledge and information. A key part of this will be to allow the industry to attract and develop fresh talent and build new skills using virtual reality and drone technology, automated manufacturing equipment and advanced robotics as part of a move towards greater productivity, through adoption of digital and industrial processes.

Example applications of immersive technology

- Virtual reality programmes to showcase to new learners the process and development of building – including integrating BIM into the programme

Success factors

- Provides an aspirational and future-focused environment in which to learn
- Recognising both the short and long-term benefits to using immersive technology in training – including how it represents an overall shift to a more digitally enabled industry

"We see a number of applications for this kind of technology. Firstly, it's about engagement – getting people excited about what construction is and what it has to offer. There's no better way to do that than by taking a headset to a careers fair. Then there's the next stage, which is about training people not only to learn specific skills but learn about overall workflow – the design process involved in construction. Being able immerse learners in the construction process and overlay BIM."

Mark Milne, Technical Manager

CHALLENGES AND CONSIDERATIONS

CHALLENGES AND CONSIDERATIONS

While the benefits immersive learning could bring to the industry represent an exciting opportunity, there are several challenges and considerations which also need to be acknowledged. These considerations integrate some of the technological considerations outlined above, but also consider issues related to current understanding of what these technologies could achieve; limitations of training environments and issues which may arise into the future.

! Limited understanding of what immersive learning is

About the challenge

- Stakeholders across the industry struggled to understand what immersive learning involves and what it could achieve. For instance, there is a perception that the technology is not scalable, due to cost and logistics, meaning that some are sceptical of its benefit. While others are simply unsure how they could use it and what technological options are available

- This attitude is perhaps the result of some training providers and employers currently lacking the digital infrastructure to support this offer or simply not having been exposed to this technology other than for entertainment purposes

- Despite this, this kind of technology is in fact far more scalable than some current training provision, given that with the cases of VR headsets, they can be used anywhere at any time, providing the mobile technology is in place

Recommendations

- Ongoing awareness raising is needed to ensure that is remains front of mind for different stakeholders in industry – this awareness raising needs to both entice excitement and interest, but also needs to be grounded in the clear and tangible benefits the technology could bring to different sectors and users

- For instance, training providers who are currently using immersive learning could act as key spokespeople and inspirational examples of what is possible and achievable

- Greater collaboration and consultation with technology companies and experts could also facilitate greater understanding internally of the benefits and limitations to the technology (this could also support content development – as below)

! Uncertainty over content development/application

About the challenge

- Related to the fact that the pace of change of these technologies is relatively quick, there was a sense amongst many that while there may be value in the technology itself, the industry currently lacks the internal capabilities to introduce this technology in an effective and sustainable way

- For instance, several providers, delivery bodies and associations who had begun to invest in these technologies spoke of their own 'learning experience' of trying to understand how content could be applied and developed to suit training. It was clear that while in many instances this yielded some exciting results, the process had been relatively fragmented

- In some cases, this meant that the content produced was not entirely fit for purpose or delivered in one area over another – such as delivering high-spec graphics and imagery over the ability to monitor and record learning progression

Recommendations

- This current challenge points to future issues around whether the industry is equipped with the internal skills and capabilities to introduce these technologies into curriculum in a way which is sustainable. Encouraging the employment of people from outside industry (such as from a technology/gaming sector) could mitigate this challenge

- Where the internal capabilities don't currently exist, it was clear that successful working partnerships with technology companies and those within the gaming industry significantly improved internal knowledge and understanding of where this tech could be applied and how. Potential partners would need to be carefully evaluated to ensure they deliver against promises/could develop the relevant content

! Unclear incentives for investment

About the challenge

- Some employers, federations and even training providers spoke of their scepticism that this type of training would yield a return of investment

- For some, it was clear that this opinion was the result of a lack of awareness of what this technology could help achieve and how it would directly impact on their current needs and challenges

- Some training providers were unsure how investment in the high set up costs associated with immersive tech would help them reach educational targets or fit in with current curriculum. Employers too were not sure how this would improve the skills and capabilities of future workers

- Those who were more certain of the return of investment and were actively trying to build a business case, were beginning to see positive feedback on the amount of training resource they had saved, the numbers trained and the overall retention of learners

Recommendations

- The most effective way to ensure that there are incentives for investment is by asking providers to develop businesses cases and evaluate the impact of their programmes. As with those sites who are already doing this, this could include training resource saved, impact on numbers trained and retention of learners into industry

- In some cases, there could be opportunity for joint delivery of immersive learning programmes with employers – ensuring that both the programme development and impact is created and monitored by and with those who are most sceptical. For instance, this research found instances where employers were creating 'apprentice challenges' to be solved through virtual learning environments. This clearly impacted on employer incentives and interest in potential employees, given that they had already been directly involved in a learner's curriculum and personal development (see Reading UTC).

About the challenge

- Given that there is no standard approach to developing the programme or curriculum for this kind of learning, there could be an issue of duplication of individual effort and unnecessary cost could be accrued across multiple training providers as a result

- For instance, while this research uncovered many exciting examples of current applications of immersive learning, it also recognised that there are several providers developing their own programmes/curriculum based on limited knowledge of the technology

- This limited knowledge could result in fragmented content and programme delivery which in turn could further heighten employer's scepticism of the quality and value of this approach to learning

Recommendations

- There is clear need to develop a more standardised/shared approach for the application of this technology

- Sharing of practice needs to be encouraged amongst those delivering training within the industry – for instance, between those who have or are implementing an immersive learning experience and between those providers who require extra support and encouragement

! Limitation of training environments

About the challenge

- If immersive learning is to be introduced across the industry, then investment will need to be made in training environments themselves – including by providing them with the support to access the tools and ongoing guidance necessary to ensure effective application

- Some providers currently are limited by poor mobile technology (such as devices and WiFi connectivity), while others could struggle to attract trainers with the adequate skills to train future workers using new and emerging digital technology

Recommendations

- Some training providers may require additional support for trainers and teachers in the first instance and then ongoing needs for different skillsets. Being encouraged to leverage expertise from other sectors (such as technology and gaming) could be a key part of this

- Greater investment needs to be made in integrating the use of digital technology into core curriculum and providers need to be supported and encouraged to do so – both in terms of guidance and funding

! Unknown physical impact

About the challenge

- While many believe that there is limited physical impact on individuals using this technology, the actual impacts are still relatively unknown

- Experts in related industries using this technology have recorded instances of users feeling nauseous and dizzy (especially when trying out tasks such as being immersed at height)

Recommendations

- Ensure that content warnings are developed within curriculum/prior to application to ensure that it warns users of the risks (especially those who may suffer from seizures or blackouts when exposed to flashing lights, pattern or sudden movement)
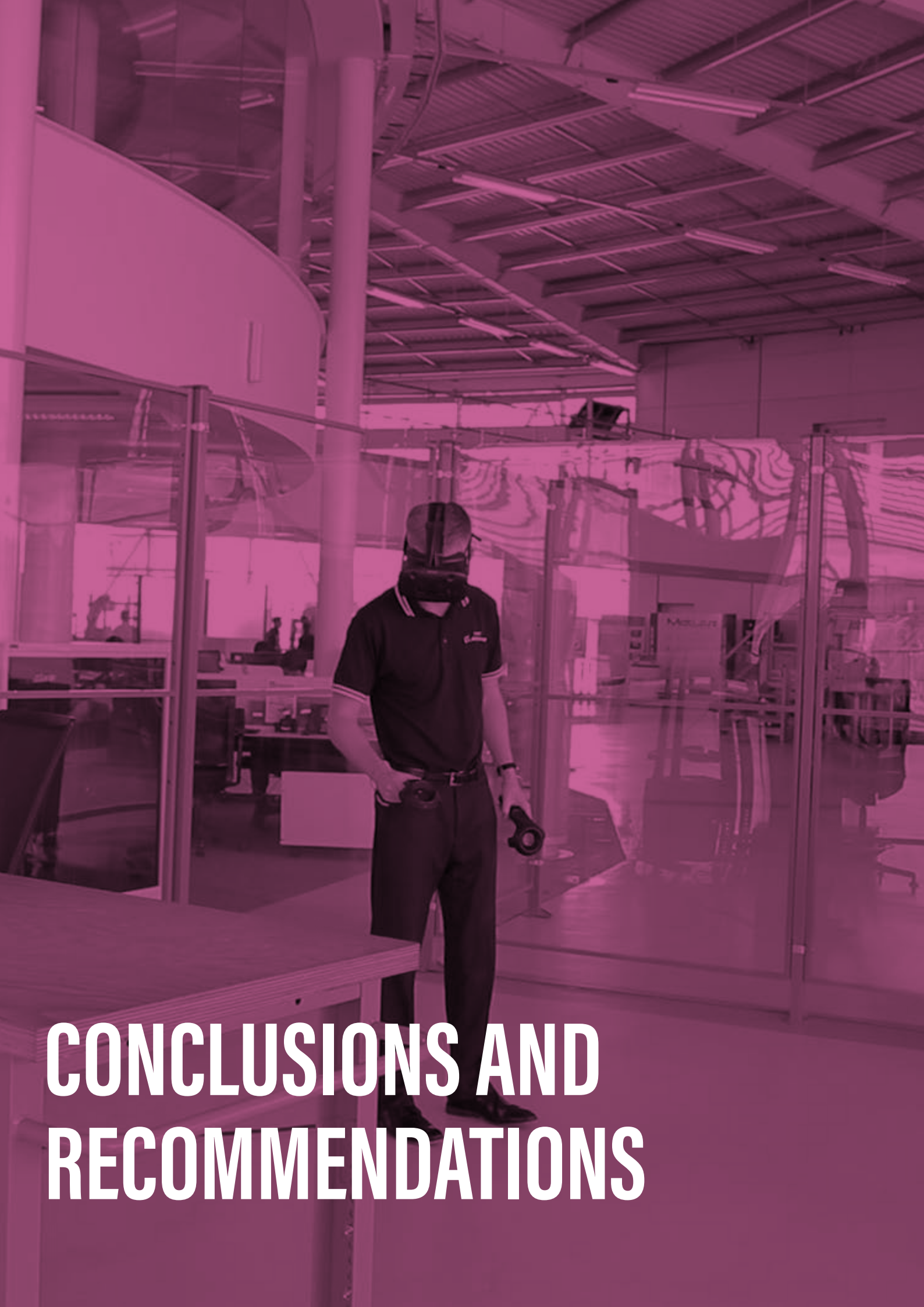
CONCLUSIONS AND RECOMMENDATIONS

CONCLUSION

This research has highlighted the numerous challenges that training providers and employers face in ensuring high quality, cost effective training. While the remedies are various and complex, our case studies have shown how introducing immersive technology – and creating a blended approach to learning – is helping to improve the quality, efficiency, safety and cost of its delivery. Our research also suggests that greater adoption of the technology, in line with targeted and successful application, could both mitigate current training challenges and deliver longer-term benefits such as increasing the appeal of the industry helping it modernise.

In the first instance, there are several key areas in construction training where this technology could be applied – specifically to support training which is higher risk, costly and requires the development of complex or technical skills. For instance, those operating machinery, learning how to handle and manage tools and materials or train their senses to work in new and potentially overwhelming construction environments. Over time this technology could also help resolve more entrenched and specific training challenges. This includes the fact that training does not always provide the level of skills industry needs, it might not provide learners with real life construction opportunities, it is often costly for both providers and employers, and in some cases, it might not attract or support qualified learners into the industry at all.

While introducing immersive technology into training will not solve these challenges in their entirety, introducing it as part of a blended learning approach will play a key role. Embracing the technology is especially important if the industry is to more widely adopt digital processes such as BIM, and attract and keep hold of the people and skills it will need to make it fit for purpose, now and in the future.

ACTIONS AND RECOMMENDATIONS

Based on the considerations and challenges, there are a number of practical steps for CITB and other key stakeholders to encourage the application of immersive learning to deliver the current and potential benefits our research has identified.

The industry requires collaboration and leadership to ensure immersive learning is introduced in the most effective and sustainable way possible, fully influencing careers, standards and qualifications, and training and development.

In particular, there is a need to:

- **Inspire adoption** through showcasing examples of best use
- **Develop and share best practice** by supporting knowledge sharing and collaboration with sectors such as gaming and considering how standardised approaches can be developed
- **Incentivise uptake** by considering policy and funding levers

In addressing these needs, CITB proposes to take the following actions, in partnership with key stakeholders:

Promote and inspire:

- In partnership with industry, promote immersive learning tools and best practice via existing channels with employers, training providers and new entrants including via Go Construct, Construction Ambassadors, schools and careers events and industry-wide conferences

- Work with training providers and forums such as the Association of Colleges, British Association of Construction Heads and the Association of Employment and Learning Providers to identify and promote case studies of benefits and challenges

- Work with government and industry, particularly in conjunction with the Construction Leadership Council, to promote the adoption of immersive learning to achieve the aims of a Sector Deal for construction, along with the wider modernisation agenda

Support collaboration and sharing of best practice:

- Commission a number of immersive learning solutions, based on the success factors highlighted in this report – which define and showcase best practice to support wider industry adoption. These solutions, underpinned by CITB funding, will specifically seek to:

  - Build capability and capacity among employers and training providers to harness the opportunities of immersive learning for the workforce

  - Coordinate development and sharing of best practice and reusable assets across the sector

  - Empower employers as leaders and proponents of the tech, encouraging providers to invest

  - Demonstrate the value of collaborations between employers, providers and experts from other sectors such as gaming

  - Ensure that interventions have well defined and measurable outputs on key performance indicators such as cost-effectiveness, skills development and retention

Further investigation:

- Use findings from funded commissions to assess the need and ability to establish formal standards on the use of immersive technology in construction

In addition, the following recommendations apply to employers and government to support the development and application of this technology:

For employers:

- Work more closely with training providers, to develop immersive solutions to key issues such as the cost/value of training and recruitment and retention of staff

- Explore opportunities for taking the hardware and visualisation software developed for specific projects, including BIM objects, and applying it to training contexts, thereby supporting curricula for apprentices and Continual Professional Development

For government:

- Work with industry, CITB and training institutions to support wider industry use of immersive technology via investment in initiatives such as Institutes of Technology, Construction Scotland Innovation Centre and Construction Wales Innovation Centre

- Building on the best-practice outcomes from the CITB commission, establish a working group to advise industry on standards and future developments in technology

- Establish a system of accreditation for educators to ensure there is a consistency of standards within the curriculum

- Undertake an inquiry into any potential health effects this technology could have with prolonged use and issue relevant guidance.

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CITB RESEARCH

Report Authors:

Catriona Hay, Damon De Ionno and Maksym Rewko, Revealing Reality.
Alan Tanner, Gareth J Williams and Ben Lever, CITB.

Commissioned by:

Stephen Radley, Policy Director at CITB,
stephen.radley@citb.co.uk

For more information please contact:

Ben Lever, CITB Future Skills and Innovation Lead,
ben.lever@citb.co.uk