CITB WHITE PAPER

A NEW REALITY:
Immersive Learning in Construction

Research Summary

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

FOREWORD

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

"The impact of immersive learning could be huge for trainers, learners and the industry. It won't take over from people-led training, but it will support it to become even better. There needs to be a plan and there needs to be standards and leadership."

Dr. Frédéric Bosché, Associate Professor, Heriot Watt University

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.

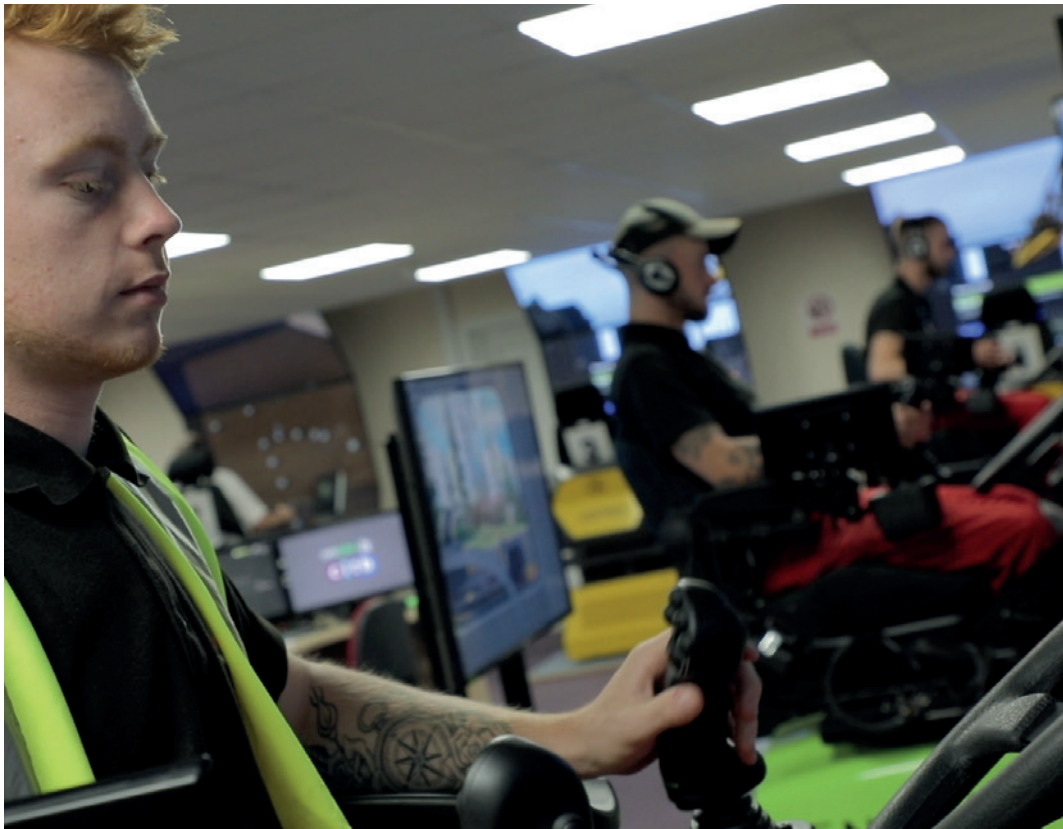
For construction as a whole, immersive learning can help develop the skills and attract the talent it needs to innovate, modernise, become more productive and deliver on the aims of the Sector Deal on which the Construction Leadership Council is working.

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.

"By using virtual reality we can provide training where employers wouldn't have to pay for workers to go offsite, but can learn about tools in an interactive environment. This doesn't mean they won't train using the real thing, but it means less time is needed for training on the equipment, therefore saving time and cost."

Richard Whiting, Commercial Manager, Hire Association Europe



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.

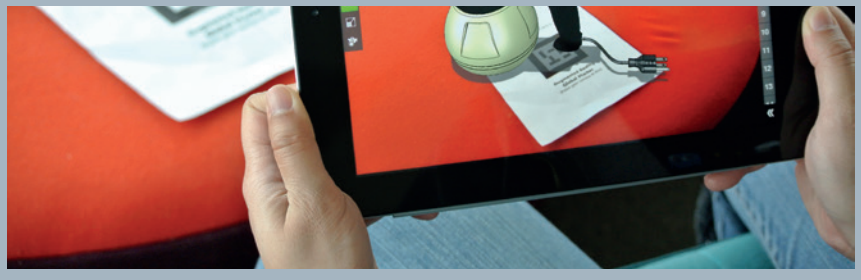
What is immersive learning?

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

"We shouldn't undersell the power of immersive technology. Immersion bridges communication and content in a way which will be necessary for the future of the industry."

Colin Sirett, Head of Research, Advanced Manufacturing Research Centre (AMRC)

THE EVIDENCE BASE

Across the UK there are pockets of immersive learning in various formats and stages. The examples below (and elsewhere in this report) demonstrate its potential and are early examples of best practice.

CASE STUDY

DUDLEY COLLEGE

Dudley College is 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 learners' 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 the 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

CASE STUDY

ADVANCED MANUFACTURING RESEARCH CENTRE (AMRC)

Advanced Manufacturing Research Centre (AMRC – part of the University of Sheffield) is keen to solve construction challenges – including waste associated with onsite installation – by including augmented and virtual reality technologies in the development of solutions for 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
- Recognising both the short and long-term benefits to using immersive technology in training – 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

CASE STUDY

CITB PLANT OPERATIONS

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.

Early feedback from Laing O'Rourke has shown it views these learners as more safety conscious and accurate than those who have not used this technology.

Example applications of immersive technology

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

Success factors

- Recognising how using immersive learning technologies can not only improve industry standards but also 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

CHALLENGES AND CONSIDERATIONS

"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."

Michael Halliday, Business Development Manager, University Technical College

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.

About CITB

CITB is the Industrial Training Board (ITB) for the construction industry in Great Britain (England, Scotland and Wales). CITB ensures employers can access the high quality training their workforce needs and supports industry to attract new recruits into successful careers in construction.

Using its evidence base on skills requirements, CITB works with employers to develop standards and qualifications for the skills industry needs now, and in the future. CITB is improving its employer funding to invest in the most needed skills and by making it easier for companies of all sizes to claim grants and support.

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

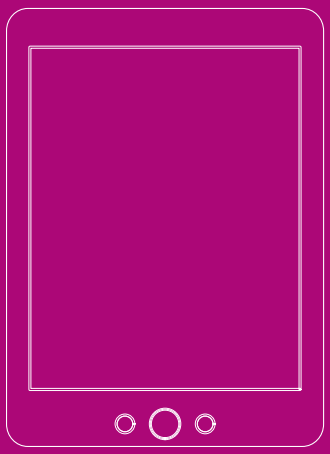
Morton Heilig wrote in the 1950s of an 'Experience Theatre' that could encompass all the senses in an effective manner, thus drawing the viewer into the onscreen activity

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

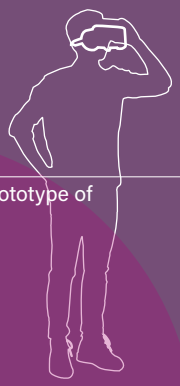
The VR industry mainly provided VR devices for medical, flight simulation, automobile industry design, and military training purposes from 1970 to 1990

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

2013

Google Glass release – first commercial AR headset



2010

Palmer Luckey designed the first prototype of the Oculus Rift

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

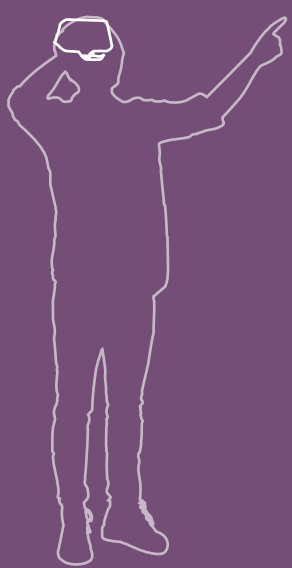
AR becoming more of a reality through the use of smartphones and headsets such as the Microsoft hololens

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



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- Dudley College
- Eversholt Rail
- Havering College
- Heriot-Watt University
- Hire Association Europe
- Home Builders Federation
- Immersive Interactive
- Interserve
- London Design and Engineering UTC
- Mace
- National Federation of Builders
- National Specialist Accredited Centre (NSAC)
- Northumbria University
- Pearsons
- Reading UTC
- Sheffield University
- University of West England
- VR Safety
- Willmott Dixon

REVEALING REALITY

Study prepared by Revealing Reality from a commission by CITB.

The views expressed by research participants are their own and do not necessarily represent those of their employers.

CITB WHITE PAPER

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