

CONSTRUCTION INDUSTRY TRAINING BOARD

Evaluation of Immersive Learning Commission - Interim Report

December 2022

CONTENTS

1.	EXECUTIVE SUMMARY	4
1.1	Key Findings	4
1.2	Lessons Learned	6
1.3	Recommended Next Steps	7
2.	TERMS OF REFERENCE AND METHODOLOGY	8
2.1	Introduction	8
2.2	Terms of Reference	8
2.3	Methodology	9
3.	IMMERSIVE LEARNING LITERATURE REVIEW SUMMARY	13
3.1	Introduction	13
3.2	Literature Review	13
3.3	Logic Model	18
3.4	Link to CITB Immersive Learning Commission	20
4.	COMMISSION OVERVIEW AND IMPLEMENTATION STATUS	23
4.1	Introduction	23
4.2	Commission rationale / context	23
4.3	Commission summary	25
4.4	Contextual Note: Impact of COVID-19	28
5.	PERFORMANCE – OUTPUTS, OUTCOMES AND IMPACTS	30
5.1	Introduction	30
5.2	Performance Against Targets per Project	30
5.3	Outcomes Achieved	32
5.4	Direct Impacts per Project	34
5.5	Indirect Impacts	36
5.6	Enablers and Barriers	39
6.	VALUE FOR MONEY / ADDITIONALITY	40
6.1	Introduction	40
6.2	Value for Money	40
7.	CONCLUSIONS AND RECOMMENDED NEXT STEPS	42
7.1	Introduction	42
7.2	Key Findings	42
7.3	Lessons Learned	44
7.4	Recommended Next Steps	45
8.	APPENDIX – PROJECT PERFORMANCE AGAINST TARGETS	46

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1. EXECUTIVE SUMMARY

The Construction Industry Training Board (CITB) immersive learning commission aimed to increase the uptake and adoption of immersive learning in the construction industry. In total £3,236,929.00¹ was initially allocated by CITB across seven (now six) interventions which aimed to²:

- apply immersive learning in innovative ways;
- test, pilot and implement immersive learning; and
- promote awareness and familiarity with the opportunities for immersive learning.

The commission commenced in June 2019 the evaluation began in February 2020, however both were suspended in March 2020 due to the COVID-19 pandemic. This impacted on what could be delivered as well as the evidence and data collected to inform the evaluation. Conclusions and recommended next steps against each of the core evaluation questions are outlined below.

1.1 Key Findings

1.1.1 Delivery and performance

- **performance against key output targets is mixed** - TunnelSkills in particular has performed very well, meeting or exceeding all targets expected to date (as of July 2022). However, all other projects have either been unsuccessful in delivering on specific output targets or have not provided evidence to show they have been achieved.
- **there were inconsistencies in output performance reporting throughout** - with the exception of TunnelSkills and CONVERT, no project was able to provide a detailed and up-to-date evidence of performance against output targets. This makes assessing performance of the overall commission difficult when key areas of projects are not assessed entirely.
- **COVID-19 is a factor that impacted delivery and the achievement of outputs** - the pandemic forced most projects to pause and / or redesign their delivery model which may have reduced momentum in meeting output targets. When lockdowns eased, employers were also less concerned with training and more with winning and delivering work.
- **notwithstanding mixed performance, almost all projects have achieved success in specific target areas** - 5 of the 6 projects provided evidence of successful delivery of immersive learning modules or training programmes. This has contributed to some of the observed outcomes and impacts such as improved health and safety skills and increased retention of skills / knowledge.

1.1.2 Achievement of outcomes

COVID-19 impacted on the ability of projects to deliver their activities as planned. Nonetheless, there is **some evidence** suggesting the projects achieved a variety of expected outcomes. These mainly relate to apprentices and school pupils developing a better understanding of what construction work entails in a safe environment, and existing staff developing their health and safety related knowledge. Three projects

¹ This includes allocated funding for the Manufacturing Technology Centre / Advanced Manufacturing Research Centre project which was not continued when the commission re-started following a pause due to the impact of Covid-19 on delivery.

Excluding this project, funding allocation totals £2,585,929.00

² CITB (2019) Immersive Learning Commission Launch Event Slides

achieved improvements in specific technical skills for apprentices using the training, such as the ability to interpret and follow technical drawings.

Some projects developed applications that trainees can download and consult after the training, potentially **increasing the likelihood of retention and behaviour change**. The interactive nature of the training courses, using headsets and tablets instead of PowerPoint, was positively received by trainees and suggested this approach helps them learn and retain the training material.

Evidence to date suggests the some of the intended outcomes from the commission has been achieved:

- apply immersive learning in innovative ways that demonstrate sustainable and scalable impact in an area with significant potential benefits – each of the six projects have applied immersive in different, innovative ways however there is not yet evidence of sustainable and scalable impacts to increase the uptake and adoption of immersive learning in the construction industry
- test, pilot and implement immersive learning with beneficiary groups employed in construction or who have the potential to become so, that stand to make significant gain from its application – five of the six projects have engaged with their target beneficiary groups to test, pilot and deliver training / learning modules (no evidence was available for the Transforming Construction Trade Apprenticeships project)
- promote awareness and familiarity with the opportunities for immersive learning among wider industry, to increase the potential for wider uptake, by showcasing funded solutions through events, forums and networks – there is evidence that two of the six projects have delivered training and careers / employer engagement events

1.1.3 Achievement of direct and indirect impacts

The **main direct impacts** include:

- **increased efficiencies** - for example, qualitative feedback from project leads suggests that using immersive learning in colleges makes it easier for those who have never been on site to experience the environment and hazards. This reduces the need for specialist on-site induction training as only those with an interest in the sector are likely to visit construction sites. Those who used the training for on-site induction of construction staff reported a 100% pass rate for the trainees.
- **more effective learning at lower cost** – for example, the use of tablets in on-site induction reduces the time required from trainers and thereby reduces costs. For example the BAM end of project report notes:

““This project has taken the challenge of traditional time-intrusive and costly inductions and utilised technology to promote learning in more engaging ways. It's more inclusive with the option to learn in different languages and the games and tests are fun but allow facilitators to check that attendees are learning – this is essential to health and safety on site. It's received great feedback from users and proved to have big time and cost savings.”

“This method of induction has reduced the time spent in induction from 3 hours to around 1.5 hours. A large saving in time and money”

- an **increased awareness** among employers and trainees and **increased** willingness to use immersive technology for either training or engagement purposes - for example, employers use TunnelSkills immersive learning content to engage apprentices.

Other less commonly reported impacts include:

- **raising awareness of and interest** in construction careers among pupils and college students. Most projects' learning materials have been used to engage young people in education and to demonstrate what construction roles look like in practice. This suggests that the Immersive Learning commission may lead to an increase in the number of people entering the industry.

Indirect impacts include:

- **greater community awareness** of construction work and what it entails among local communities adjacent to tunnelling sites.
- **other impacts** and outcomes for indirect beneficiaries are similar to outcomes for the direct beneficiaries, including improved health and safety knowledge and an increased understanding of construction sites.

Value for Money

To conduct a quantitative VfM assessment a minimum of the following data should be captured from each project in addition to the funding schedules and monitoring information :

- number of employees trained.
- job retention / employment rates.
- reduction in health & safety costs / claims.
- reallocation of time dedicated to on-site production of construction services away from training. (cost saving, revenue generation)
 - more efficient use of on-site production of construction services.
- improved future training and subsequent construction industry attractiveness as a place of work.
- wider benefits could be experienced such as improvements in infrastructure development.

1.1.4 Counterfactual impact of the commission

While project leads suggested that the training content and outputs would not have been developed and delivered without CITB funding, there is insufficient evidence to conclude on what might have happened if the CITB funding had not been available and what additionality the funding provided.

1.2 Lessons Learned

Key lessons learned to date that can be taken forward include:

- **project leads and partners are positive about the future scalability of the immersive learning projects** - however, they highlighted a number of factors that should be considered to enable scaling up the projects, including:
 - the need to support trainers and colleges on how to use hardware and headsets and providing troubleshooting guidance

- developing more content for mobile phone apps, as opposed to virtual reality content for headsets which are expensive and limit the number of employers and training providers who can access the content
- **information about outcomes achieved for trainees is difficult to capture through project lead and partner interviews** - it is important that training is followed by a short, consistent survey of trainees with a follow-up survey c 3 – 6 months later to find out if and how they applied what they had learnt. The survey should capture the trainees' experience of using the training as well as what they learned and how they are likely to use what they learned in future.
- **it is important to engage the right partners at the right point in time** - to ensure that construction companies have live projects on which to roll out content. In addition, engaging partners requires the project leads to invest time and resources, therefore it may be more productive to engage partners sequentially, depending on resources available.

1.3 Recommended Next Steps

In order for immersive learning to become central to training and development delivery, it is essential there is robust evidence that it works. The impact of COVID-19 on the commission and the lack of data collected by some of the projects has made it difficult to produce this evidence.

The projects still ongoing are particularly important in ensuring that evidence is collected to demonstrate how immersive learning can reduce costs of training as well as increase uptake, skills and learning. This will be key to the future sustainability of immersive learning.

Next steps for the remainder of the commission include:

1. Collection of outcome information from project participants, including contact information for follow up consultations by RSM. **Responsibility: Project Leads** (RSM to provide guidance on data needed by to all projects still ongoing)
2. Work with projects that are still live to ensure their data collection tools collect all evidence needed against the evaluation questions. **Responsibility: RSM to meet and provide guidance on the tools, CITB to provide communications and Project Leads to collect the data**
3. Reiterate to projects the need to collect and share monitoring data and participant feedback with RSM. **Responsibility: CITB**
4. Develop case studies with projects still ongoing that will demonstrate the costs and benefits of immersive learning. **Responsibility: RSM** in conjunction with the **Project Leads**
5. Additional data on activities to be collected to inform the value for money and additionality assessment in the final report (details on minimum activity data required in section 6.2). Where applicable, follow-up surveys to be completed with those supported to capture if and how they were able to implement the training or learning provided, and if they did would they have been able to do this without the support provided **Responsibility: RSM** in conjunction with the **Project Leads**
6. Consideration to be given to how project outputs and content from the final evaluation could be promoted to CITB's wider membership. **Responsibility: CITB** (options to include an event and promotion of the case studies)
7. CITB to work with projects to consider scale up options. **Responsibility: CITB after the final evaluation report.** Note the final evaluation report will cover the costs and benefits emerging from the pilots

2. TERMS OF REFERENCE AND METHODOLOGY

2.1 Introduction

RSM UK Consulting LPP were appointed by the Construction Industry Training Board (CITB) in 2020 to complete an interim and final evaluation of its immersive learning commission.

In total £3,236,929.00³ was initially allocated by CITB across seven (now six) interventions which aimed to increase the uptake and adoption of immersive learning in the construction industry. Specifically, they aimed to⁴:

- apply immersive learning in innovative ways;
- test, pilot and implement immersive learning; and
- promote awareness and familiarity with the opportunities for immersive learning.

The commission commenced in June 2019 the evaluation began in February 2020, however both were suspended in March 2020 due to the COVID-19 pandemic. This impacted on what could be delivered as well as the evidence and data collected to inform the evaluation. This **interim report** includes:

- a review of the rationale and overview of the Immersive Learning Commission;
- a summary of commission delivery and implementation;
- performance to date based on analysis of monitoring information submitted by the funded projects to CITB and feedback from project leads and partners; and
- key findings / recommended next steps.

The final report will be produced in April 2023.

2.2 Terms of Reference

The specification for this evaluation stated the following requirements:

(1) to assess the direct and indirect impact of each completed project for all beneficiaries and stakeholders;

(2) to investigate if the counterfactual impact of the commission could be calculated, i.e. what might have happened if the funding had not been available and what additionality CITB funding provided; and

(3) to determine whether the outcomes of the commission have been achieved.

In addition, in July 2022 CITB asked for any evidence on whether the commission has had a positive influence on one or more of the following points:

- bringing more people into industry
- training capacity (e.g., if fewer people are needed to do some of the teaching)
- the training assessment process

³ This includes allocated funding for the Manufacturing Technology Centre / Advanced Manufacturing Research Centre project which was not continued when the commission re-started following a pause due to the impact of Covid-19 on delivery.

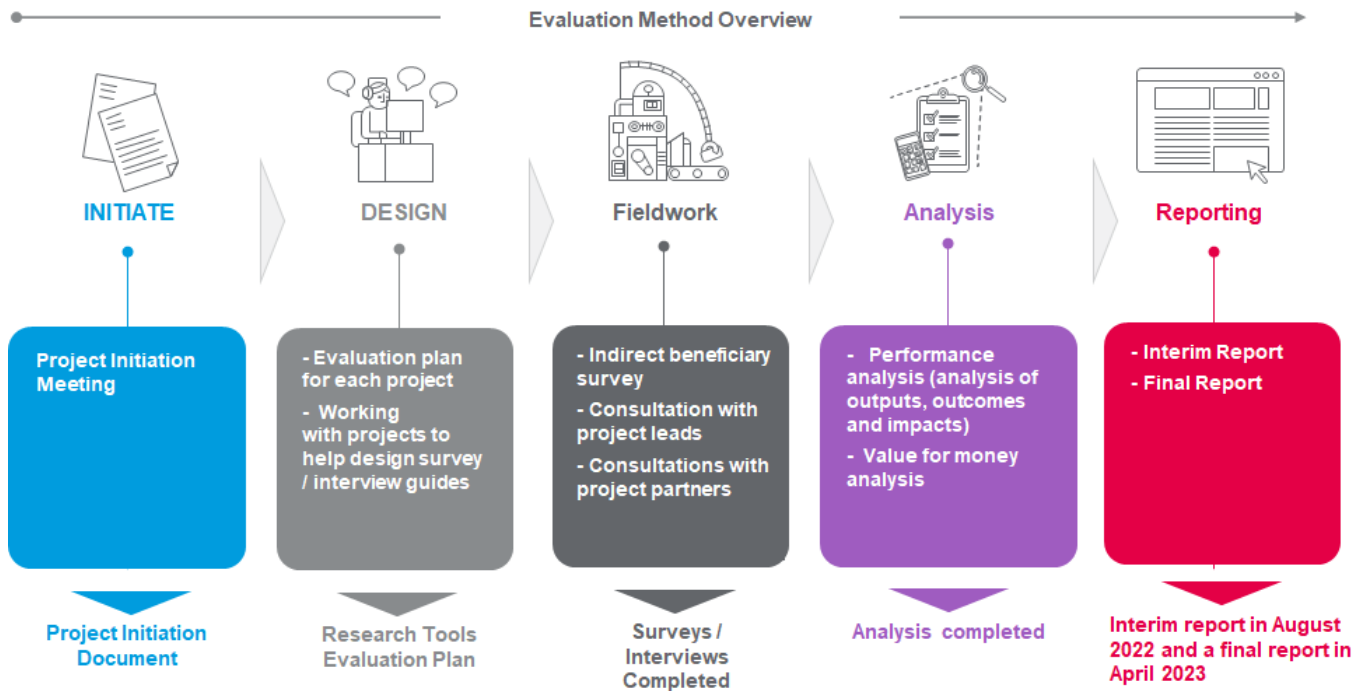
Excluding this project, funding allocation totals £2,585,929.00

⁴ CITB (2019) Immersive Learning Commission Launch Event Slides

2.3 Methodology

Our methodology involved 5 phases: initiation, design, fieldwork, analysis and reporting. The following diagram provides a high level overview of our methodical approach:

Figure 1: Methodology Overview



At the outset of the evaluation, RSM worked with each project to design data collection tools such as surveys and interview guides that could be used to capture feedback from trainees and other beneficiaries / stakeholders during project delivery and at completion. Projects were required by CITB to collect this data during delivery.

These tools were used to different degrees across the projects and the sources of performance, funding output and outcome data are summarised in the following table. The interim report is valuable in highlighting the gaps in information that can be followed up on for the final report (see table 1).

As required by the invitation to tender the possibility of calculating the counterfactual impact of the commission (i.e. what might have happened if the funding had not been available and what additionality CITB provide) was investigated as part of the evaluation plan. The following options were explored however agreed with CITB as not feasible:

1. Survey completed by RSM with project partners from organisations that did not receive CITB funding (ie were unsuccessful in their application) to determine what they did instead, e.g. did they fund the project themselves; obtain funding from elsewhere for the project; obtain funding for a different project; or did not deliver the project. **Not feasible** – as this was dependent on CITB being able to provide contact details for unsuccessful applicants which was not feasible given the lapse in time since their original application and the landscape of industry has also changed significantly.
2. Interview or surveys completed by RSM with companies that did not apply however have funded immersive training from their own funds to determine if their initiative progressed as planned and what results have been achieved. **Not feasible** – as this was dependent on CITB being able to identify companies they would have expected to apply for funding via the immersive learning commission

however did not which CITB confirmed was highly unlikely and the landscape has also changed significantly.

Therefore a **non-experimental counterfactual was chosen**, specifically by including questions within the employers / trainers / learners surveys on what they would have done without the project / commission and what impact this would have likely had on skills and business results. However the robustness of this approach is dependent on what surveys were administered by the lead partner and if these included questions on the counterfactual. Insufficient data was collected at the interim report stage to conclude on the counterfactual impact.

Table 1: Project Description and Data Collection

Project Title and Description	Funding paid by CITB (to date 08/12/2022) ⁵	Data collected	Data to be collected
<p>BAM Nuttall (Improving Behavioural Induction for Highways)</p> <p>Aim: reduce teaching time and improve memory retention for behavioural induction training using augmented reality.</p>	£244,309	<p>End of project report submitted to CITB by BAM Nuttall:</p> <ul style="list-style-type: none"> refers to positive feedback received on the services provided however does not contain details on how this feedback was collected or the number of responses received contains detail on performance against some targets however not all and lacks detail on how the targets were met 	<p>To be agreed with CITB and the project lead what is feasible now the project is complete.</p> <p>Greater evidence is needed on activities / outputs delivered and performance against targets and objectives (see appendix A)</p>
<p>TunnelSkills Specialist Training Forum (TunnelSkills)</p> <p>Aim: utilise a mix of VR and AR to both develop training and induction systems and build awareness of the tunnelling sector.</p>	£239,108	<ul style="list-style-type: none"> Trainees / learner feedback forms designed and administered by the project (n=77⁶) Event attendee feedback forms designed and administered by the project (n=63) Payment and Reporting Schedule (June 2022) submitted to CITB (analysis is included in section 5.2) 	<ul style="list-style-type: none"> The final apprentice end point assessment will be conducted by TunnelSkills c. December 2023 Further trainee survey feedback is currently being collected and collated Case studies
<p>Construction Wales Innovation Centre (CWIC) (Construction Virtual Environment Resource Training (CONVERT))</p> <p>Aim: deliver a GB-wide physical infrastructure that will provide a</p>	£ 1,278,707	<p>Learner and employer feedback surveys designed and administered by the project. The feedback for each was added into the same survey, meaning distinctions in response numbers between the two cannot be made. Overall, 151 survey responses were received</p>	<ul style="list-style-type: none"> 1 project partner feedback form is yet to be completed Follow-up surveys with learners and employers Case studies

⁵ Financial information provided by CITB to RSM UK Consulting (December 2022)

⁶ Of these 77, 14 are Tunnelling Apprentices (also Construction risk facing), 33 are in a school/college/uni versity environment (including teachers) or not in employment, 14 are working in construction (non-risk), and 16 are working in construction (risk-facing).

Project Title and Description	Funding paid by CITB (to date 08/12/2022) ⁵	Data collected	Data to be collected
sustainable and scalable immersive learning solution.		Project partner feedback forms designed and administered by the project (n=3) Payment and Reporting Schedule (April 2022) submitted to CITB (analysis from this is included in section 5.2)	
Bridgwater and Taunton College (Transforming Construction Trade Apprenticeships) Aim: support colleges delivering the apprenticeship requirement for 20% off-site learning for steel fixing drawing and sharp codes.	£157,476	No monitoring, output or outcome data was provided by Bridgewater and Taunton College.	Information required includes: <ul style="list-style-type: none"> • Data on performance against targets • Feedback from trainees (apprentices) and colleges on the outcomes achieved
City College Plymouth (Immersive Learning for Construction – Plymouth) Aim: reduce learning hours and increase retention of students using immersive learning methods.	£270,567	Monitoring data collected on participation, engagement, demographic information and project impact Learner feedback surveys designed and administered by the project (n=50)	To be agreed with CITB and the project lead what is feasible now the project is complete. Greater evidence is needed on activities / outputs delivered and performance against targets and objectives (see appendix A)
Hire Association Europe (HAE) (Mixed Reality Training Vehicle for Specialist Learning) Aim: develop a web-based content creation platform and community space, allowing users to generate their own learning experiences.	£191,804	<ul style="list-style-type: none"> • Payment and Reporting Schedule (June 2022- output data provided up to November 2021) submitted to CITB (analysis from this is included in section 5.2) 	Information required includes: <ul style="list-style-type: none"> • Up to date data on performance against targets and objectives • Feedback from users on the outcomes achieved • Case studies

In addition to the information collected by the projects above RSM completed:

Interviews with project leads:

- TunnelSkills
- CONVERT
- Improving behavioural induction for highways
- Transforming construction trade apprenticeships
- Mixed Reality Training Vehicle for Specialist Learning
- Immersive Learning for Construction – Plymouth

Interviews with project partners:

- TunnelSkills – 4 partners
- CONVERT – 2 partners
- Improving Behavioural Induction for Highways – 0 partners (1 partner provided but were not available for interview until September. No response following 3 requests for contact details of other partners)
- Transforming Construction Trade Apprenticeships – 0 partners (Received verbal confirmation from the lead that they will contact partners, but none have been provided yet)
- Mixed Reality Training Vehicle for Specialist Learning – 0 partners (no response following 4 requests)
- Immersive Learning for Construction – Plymouth – 0 partners (Received verbal confirmation from the lead that they will contact partners, but none have been provided yet)

Survey of indirect beneficiaries:

- A survey was developed by RSM and provided to project leads for distribution to their indirect beneficiaries and the responses were:
 - TunnelSkills - 13 complete responses (72.2% response rate)
 - CONVERT - 8 complete responses from the project (61.5% response rate)
- Note: 1 response was received but did not specify which project they were involved in (either CONVERT or TunnelSkills)

Limitations

The COVID-19 pandemic impacted delivery of the CITB immersive learning projects. Each project continued to varying extents however the project timelines for each have been revised since the original applications and while some are now completed, others are still ongoing (see section 4.4). As a result, in some cases there is limited information and data on the outcomes and impacts achieved to date and the evidence available is indicative.

In addition, as each project submits their quarterly report / data to CITB at different times, for some the most recent data available for analysis did not cover the same timeframe as the financial data shared by the CITB commissioning team. As a result, an accurate cost per participant analysis was not possible and **caution should be applied if considering spend alongside performance.**

3. IMMERSIVE LEARNING LITERATURE REVIEW SUMMARY

3.1 Introduction

This section outlines the findings from a rapid review of recent literature on where immersive learning can have the most impact to identify potential success measures for the commission, and how the CITB funded projects link to these. This was used to inform development of a logic model (see section 3.3).

3.2 Literature Review

This section considers the areas where immersive learning could have the most impact, as well as identifying how these link to the CITB Immersive Learning commissioned projects and the opportunities for these interventions if they are proven to be effective. It details key outcomes / impacts within the sector, and specific benefits related to the use of virtual and augmented reality.

3.2.1 Methodology

The approach to identifying evidence involved a purposive process to searching key terms (e.g., 'immersive learning in construction', 'virtual reality in the construction industry', 'new technology in construction training' and 'the benefits and challenges of immersive learning in construction') in journals and research papers, as well as policy papers and corporate documents. The search engines and publisher repositories consulted includes Google Scholar, Springer Link, Wiley Online Library and Social Science Research Network (SSRN) Online Library.

This literature review includes 16 separate pieces of literature published over the last 10 years to ensure that a wide range of sources are reviewed, whilst also maintaining a relevance to the current position of immersive learning in the industry, with descriptive information being extracted to provide evidence of:

- opportunities for immersive learning in the Construction Sector;
- outcomes / impacts of immersive learning methods in the construction sector;
- benefits of immersive learning methods; and
- how these key findings link to the CITB Immersive Learning projects relevant to this evaluation

3.2.2 Key Findings

Opportunities for Immersive Learning in the Construction Sector Evidence

Opportunity 1 – Incorporating immersive learning methods, such as virtual reality into health and safety and other more specific construction training areas, can result in increased focus and interest in the training itself, resulting in long term benefits such as knowledge retention and employee satisfaction.

According to research conducted by Sacks, Perlman and Barak⁷, virtual reality safety training has a greater impact on those participating in it than safety training utilising more traditional methods. This study involved an experiment with 66 subjects, with half experiencing traditional methods of training, such as in-classroom visual aids, and half experiencing the immersive learning training. The group's knowledge on the subject of safety in construction was tested prior, immediately after, and 1 month following the training. The research showed that virtual reality training was more effective in maintaining

⁷ Sacks, Rafael. Perlman, Amotz and Barak, Ronen (2013). Construction safety training using immersive virtual reality

the trainees' attention and concentration. As a result, the report strongly recommended the adoption of virtual reality in construction safety training given the need for improved training and the advantages of using the virtual reality materials. This highlights the opportunity for immersive learning to improve the provision of health and safety training in the construction industry through the increased enjoyment and proactive involvement from the trainee base via the use of immersive learning materials such as virtual reality headsets.

This perspective is furthered by research⁸ into the creation of immersive learning systems for the purpose of training, splitting two groups evenly (groups of 10 with an equal number of men and women in each) with one group completing real-world training and the other completing virtual reality training instead. The results indicated that, although there was no difference in learning outcomes between the two groups, the number of errors experienced during the virtual reality training were significantly lower. This made for a more positive experience for the trainees, with the research conducted also highlighting the positive nature of the virtual reality training, providing an immersive experience with fun and visual feedback that can help to stimulate visual learners.

The potential for immersive learning methods to improve safety levels in construction is further evidenced by an empirical study⁹ attempting to quantify the effectiveness of VR methods across six worker specialities facing 17 hazardous scenarios at real construction sites. Of the 80 participants, 40 were novice workers (college students) and 40 were experienced workers. Results showed that:

- the safety performance index of all 80 participants increased by 14.12% in terms of correct selection of personal protective equipment and 28.95% in terms of hazardous scenario identification ; and
- improvement of safety learning performance of the novice workers was better than that of the experienced workers (especially for hazardous scenario identification), with a 15.9% higher improvement index

It is important to consider how to develop and deliver immersive learning methods effectively as well as their potential impacts. Recent research¹⁰ has aimed to synthesize the outcomes criteria for measuring the effectiveness of this training in different work sectors through a review of relevant literature. This found that virtual environment techniques (VETs) have advantages, such as improvements in performance in an immersive risk-free learning environment and also provided practical implications for the use of this technology moving forward:

- a training programme for workers should be tested with workers rather than students the sample size for tests / studies should be estimated with consideration for the effect size desired
- the method selected should match the training goal (e.g., information-based methods should support trainees in knowledge transfer and demonstration-based methods should enable trainees to observe the correct safety procedures.¹¹

⁸ Li, Sansan and Zhou, Dongxian (2021) The construction of immersive learning system based on virtual testing technology of virtual reality

⁹ Yu, Wen-Der et al (2022) Empirical Comparison of Learning Effectiveness of Immersive Virtual Reality–Based Safety Training for Novice and Experienced Construction Workers

¹⁰ Rey-Becerra, E et al. (2021) The effectiveness of virtual safety training in work at heights: A literature review

¹¹ Rey-Becerra, E et al. (2021) The effectiveness of virtual safety training in work at heights: A literature review

Opportunity 2 – The opportunity to develop specific skillsets in the construction industry where immersive learning methods are proven to be more effective in training and skill development.

A key example of this was noted by Jason Lucas¹², who assessed the use of immersive virtual reality for learning to increase student understanding of sequence, assembly, and space of wood frame construction. This research found that 93% (23) of the participants in the research responded positively to the adopted use of virtual reality headsets, with areas of its use such as comfort and the lack of nausea, anxiety and vertigo all being noted during research. This highlights the overall positive reception to this new learning method, but the research sought to look deeper into immersive learning's role in very specific areas of construction training. As a result, an assessment was conducted of how training in the areas listed above via immersive learning methods compared to traditional methods, with only 1 participant in the experiment feeling that the latter was more effective. A total of 64% of the participant base felt that virtual reality provided them with an improved understanding of the topic, with 32% feeling neutral.

Overall, the study concluded that virtual reality had real potential in developing student understanding of areas such as the assembly of construction components, highlighting the opportunity presenting itself to test virtual reality and other immersive learning training methods against more traditional systems to assess whether improvements to skill development and user experience could occur as a result.

Opportunity 3 – The adoption of immersive learning methods in construction could result in a cost reduction for both suppliers and consumers

This opportunity is based on the concept that the adoption of immersive learning technology can contribute to the removal of a key cost area of the construction life cycle (rework and design deviation costs). Academic research has highlighted the potential for immersive learning technology to minimise errors such as these and remove these costs by eliminating design error. Technology such as virtual reality / augmented reality and 3D / 4D visual imaging technologies can help to do this by monitoring the build process and identifying issues in a timely manner in order to mitigate cost consequences, as well as providing a more in-depth and educational design experience at the start of the construction process.¹³

This opportunity relates to both new entrants to the industry as well as experienced construction professionals as all would make use of such technology if the challenges listed above were avoided or mitigated. The literature also suggest that reduced construction costs would contribute to the reduction of costs incurred by the consumer.

This perspective is supported by other academics who also recognise the potential for immersive learning technology to provide increased insights into the construction process and ensure a more accurate build through the ability to compare as-planned and as-built conditions of the project in real time which will act as a cost reduction factor through the minimising of build deviation costs.¹⁴

¹² Lucas, Jason (2018). Immersive VR in the construction classroom to increase student understanding of sequence, assembly, and space of wood frame construction.

¹³ Chowdhury, Tabinda. Adafin, Johnson and Wilkinson, Suzanne (2019). Review of Digital Technologies to Improve Productivity of New Zealand Construction Industry

¹⁴ Safikhani, Saeed. Keller, Stephen. Schweiger, Gerald and Pirker, Johanna (2022). Immersive virtual reality for extending the potential of building information modeling in architecture, engineering, and construction sector: systematic review

Opportunity 4 – Immersive learning technology can provide a more accessible alternative to on-site experiential learning in the construction industry.

As noted by several researchers, virtual reality and other forms of immersive learning represent an opportunity for the construction industry to make training more accessible.. This is perhaps clearest in the area of health and safety, where tertiary education providers often struggle to provide on-site experiential learning opportunities for their students as a result of the high-risk nature of construction sites. Virtual reality models, therefore, represent an alternative way of providing this experiential learning opportunity whilst ensuring that risks to students are minimised. However this is reliant on immersive learning methods being as useful to students as a real-life visit to a site can be.

Research has been conducted that assesses the efficacy of virtual experiential site learning against real-world site experience, with researchers creating a virtual reality model to simulate a construction environment. Construction students were asked to evaluate their experience of this model and compare it against experiences on actual sites, with the results showing that the VR model could provide an intuitive and safe way to engage these students. 71.5% of learners involved in this research project believed that VR models are useful in construction studies as a result of their increased convenience and felt it added to their learning experience. This highlights the potential of immersive learning to mitigate certain health and safety risks associated with experiential learning in the construction industry, whilst ensuring that students receive an immersive education in key areas. However, research also notes that this could benefit the learning providers as well as the students, offering them a chance to engage with experiential learning activities which could improve their teaching quality and make the learning process more enjoyable. ¹⁵

Construction Sector Evidence of Outcome / Impacts

This section outlines the financial and non-financial outcomes / impacts identified in the literature. The most commonly identified non-financial benefits are: reduction of safety concerns, flexibility of training (e.g., frequency, content etc.), increased engagement/motivation of trainees and improved quality of training (i.e., improved skills / retention).

Examples of evidence of positive outcomes / impacts resulting from immersive learning listed in the opportunities section of this literature review include:

- Research showing that immersive learning methods were more effective in ensuring longer term knowledge development than more traditional methods (opportunity 1)¹⁶
- Research showing that the number of errors experienced during training was lower for training utilising immersive learning technology than it was for training using more traditional methods (opportunity 1)¹⁷
- Research showing that a majority of the group used for the analysis (64%) felt that their understanding of a specific subject within construction had improved as a result of their use of immersive learning technology (opportunity 2)¹⁸

¹⁵ Samarasinghe, Don Amila Sajeevan. Latif, Suhaimi Abd and Baghaei, Nilufar (2019). Virtual Reality Models for Promoting Learners Engagement in Construction Studies

¹⁶ Sacks, Rafael. Perlman, Amotz and Barak, Ronen (2013). Construction safety training using immersive virtual reality

¹⁷ Li, Sansan and Zhou, Dongxian (2021) The construction of immersive learning system based on virtual testing technology of virtual reality

¹⁸ Lucas, Jason (2018). Immersive VR in the construction classroom to increase student understanding of sequence, assembly, and space of wood frame construction.

- In research assessing the role of immersive learning compared to traditional methods in providing experiential learning, 71.5% of learners involved believed that VR models were useful in construction studies as a result of their increased convenience and felt it added to their learning experience (opportunity 4)¹⁹

Table 2: Benefits Evidence

Virtual Reality (VR)²⁰

Source	Benefits
Ventura, SM. Castronovo, F. Nikolic, D and Ciribini, A L.C (2022) Implementation of virtual reality in construction education: a content-analysis based literature review	<ul style="list-style-type: none"> • Head-mounted displays and room-like VR is argued to support egocentric experience of the spaces and, as a result, lead to better understanding of the relative sizes of the spaces to their scale • Provides ability for students to dynamically interact with information, test concepts and receive feedback
Wang, P. Wu, P. Wang, J. Chi, H-L and Wang, X (2018). A critical review of the use of virtual reality in construction engineering education and training	<ul style="list-style-type: none"> • Building Information Modelling (BIM)-enabled VR helps students identify buildings in detail and can enhance students' spatial understanding
Jeelani, I. Han, K and Albert, A (2020). Development of virtual reality and stereo-panoramic environments for construction safety training	<ul style="list-style-type: none"> • Researchers assessed the impact of the use of stereo-panoramic environments using real construction scenes and a virtual construction site compared to more traditional methods of health and safety education in a before and after study. Research uncovered a 39% improvement in hazard recognition and a 44% improvement in hazard management performance
Rebelo, F. Noriega, P and Veronesi, J (2018). A framework to use virtual reality for behaviour change to promote safety and health at work	<ul style="list-style-type: none"> • Use of VR in safety training can not only improve health and safety awareness, but can also influence their routine behaviours in an unconscious manner

Table 3: Benefits Evidence – Augmented Reality (AR)²¹

Source	Benefits
Chen, K and Xue, F (2020). The renaissance of augmented reality in construction: history, present status and future directions	<ul style="list-style-type: none"> • AR can be particularly useful in design, construction, and operation stages of project development
Chai, C. Mustafa, K. Kuppasamy, S. Yusof, A. Shien Lim, C and Wai, S H (2019). BIM integration in augmented reality model	<ul style="list-style-type: none"> • Integrating BIM with AR is believed to increase BIM's applicability to fieldwork, with results of research into this showing that BIM is compatible for integration with the AR platform
Nassereddine, H. Schranz, C. Hatoum, MB and Urban, H (2020). A comprehensive map for integrating augmented reality during the construction phase	<ul style="list-style-type: none"> • Research noted that the 5 core benefits of the use of AR in construction are enhancing decision making, improving collaboration and communication, improving productivity, providing additional resources for problem

¹⁹ Samarasinghe, Don Amila Sajeevan. Latif, Suhaimi Abd and Baghaei, Nilufar (2019). Virtual Reality Models for Promoting Learners Engagement in Construction Studies

²⁰ 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

²¹ 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

Source	Benefits
	solving and reducing wastes, defects and construction reworks
Kwiatk, C. Sharif, M. Li, S. Haas, C and Walbridge, S (2019). Impact of augmented reality and spatial cognition on assembly in construction	<ul style="list-style-type: none"> • Research conducted into the role AR could play in the assembly process in construction produced positive results, with 21 professional pipe fitters and 40 engineering students used as research participants. their spatial cognitive abilities are measured and then asked to assemble a complex pipe using either traditional or AR assisted means. Results were beneficial from an AR perspective, showing that AR can save substantial time in assembly over conventional methods for both untrained engineers and professionals

3.3 Logic Model

3.3.1 Overview

A logic model approach is used to represent the theory of how an intervention produces its outcomes. The logic model details the links between the inputs, activities and expected outputs, outcomes and impacts for the CITB immersive learning commission. It provides the basis for the evaluation to explore to what extent objectives have been met and whether planned outputs, outcomes and impacts have been achieved.

The logic model is illustrated in figure 2 which was informed by the findings from the literature review in section 3.2.

The logic model was used to inform the assessment of outcomes and impacts in sections 5.3 and 5.4.

Figure 2: Logic Model

Inputs	Activities	Outputs	Outcomes	Impact - uptake and implementation of immersive learning
<ul style="list-style-type: none"> CITB funding commission (Flexible and Structured Fund) for workers in the construction industry in GB²² – CITB Funding Co investment CITB / project partner(s) staff time 	<ul style="list-style-type: none"> Setting up processes to deliver the commission / projects Procurement of projects Project promotion / marketing to construction sector supervisors / managers and employees Development of learning modules / scenarios / assets Development of resources Attracting companies / trainees Collaborating with other companies / sectors / experts 	<p>Six immersive learning projects delivered to target groups in the construction industry (employers and employees). Examples include:</p> <ul style="list-style-type: none"> Completion of VR / AR / other learning modules Development of online framework / portal Behavioural learning completed Learning scenarios and digital assets developed Web based platforms developed <p>Engagement levels – measured by, for example:</p> <ul style="list-style-type: none"> Time spent with learning modules / system How often they return to it <p>Usability features - for example: clarity of instruction, engagement, enjoyment, realism, comfort, interactivity, ease of use</p>	<ul style="list-style-type: none"> Increased collaboration and communication skills²³ Increased problem-solving skills²⁴, including in potentially dangerous situations, locations or equipment Increased critical thinking²⁵ Increased technical and creative skills²⁶ Increased specific technical skills (relevant to project e.g., tunnelling etc) Increased safety²⁷ / injury rate reduction Improved quality and outcomes of training (e.g., opportunities to experience greater range of scenarios; undertake problem solving; enable greater experimentation) 	<ul style="list-style-type: none"> Increased awareness of immersive learning to address skills challenges Employers more willing to use immersive technology where appropriate Students empowered to strategise and make their own decisions (learning from successes and failures) Increased efficiencies (due to minimisation of offsite time, including regular updating of skills or knowledge) More effective learning at a lower cost²⁸ and less time:²⁹ <ul style="list-style-type: none"> reduced time taken to learn decreased number of trainee errors increased amount learned learners retain knowledge longer than traditional methods increased efficiency

²² 4 projects are GB wide, 1 is in England, Scotland and Wales and 1 is in the South West

²³ CITB (2017) A New Reality: Immersive Learning in Construction

²⁴ CITB (2017) A New Reality: Immersive Learning in Construction

²⁵ Cognizant (2018) Bringing Learning to Life through Immersive Experiences

²⁶ Cognizant (2018) Bringing Learning to Life through Immersive Experiences

²⁷ Allows learning to test their skills / explore outcomes with no threat to their safety or damage to equipment

²⁸ Can include cost of delivering the training as well as providing individual and tailored feedback to trainees

²⁹ J. D. Fletcher et al., “Effectiveness of augmented reality & augmented virtuality,” presented at MODSIM World 2017 Conference

To provide evidence against the CITB immersive learning commission KPIs, the metrics which are most important are:

Outcomes	<ul style="list-style-type: none"> • Increased problem-solving skills³⁰, including in potentially dangerous situations, locations or equipment • Increased specific technical skills (relevant to project) • Increased retention in training and of skills / knowledge • Improved quality and outcomes of training (e.g., opportunities to experience greater range of scenarios; undertake problem solving; enable greater experimentation)
Impacts	<ul style="list-style-type: none"> • Increased efficiencies (due to minimisation of offsite time, including regular updating of skills or knowledge) • More effective learning at a lower cost³¹ and less time³²

The logic model was used to inform the development of the some of the research tools which collected evidence against the planned outputs, outcomes and impacts at project and commission level as well as key learnings.

3.4 Link to CITB Immersive Learning Commission

This section links the research analysed for the literature review and the specific projects relevant to the immersive learning commission, providing examples of where the projects link to specific outcomes from the logic model.

3.4.1 Improving Behavioural Induction for Highways – BAM Nuttall Ltd

The immersive learning project developed by BAM Nuttall possesses features that relate to several areas of immersive learning discussed throughout this review, as well as outputs within the commission’s logic model. This is highlighted by one of its core purposes being to reduce induction times and improve memory retention and behaviour. As discussed in the opportunities section of this review, improved memory retention and training convenience are some of the key opportunities that present themselves through the use of immersive learning technology. As well as this, the project seeks to make use of a virtual reality game, with the benefits of VR’s use being outlined above. As shown in the logic model below, the project relates to several outcomes. The most direct relations are provided below:

- increased retention in training and of skills / knowledge; and
- behaviour alteration

³⁰ CITB (2017) A New Reality: Immersive Learning in Construction

³¹ Can include cost of delivering the training as well as providing individual and tailored feedback to trainees

³² J. D. Fletcher et al., “Effectiveness of augmented reality & augmented virtuality,” presented at MODSIM World 2017 Conference

3.4.2 Immersive Learning for Construction – City College Plymouth

This project's focus on utilising VR and AR methods to replicate house-building working environments links it closely to the benefits listed for each above, including opportunities to avoid deviations in the building process as well as increased knowledge retention and engagement. This project's focus on improving the training experience for new recruits also causes it to align further with outcomes from the logic model, with this shown below:

- improved quality and outcomes of training (e.g., opportunities to experience greater range of scenarios; undertake problem solving; enable greater experimentation)
- increased specific technical skills (relevant to project)

3.4.3 Transforming Construction Trade Apprenticeships – Bridgewater and Taunton College

This project is focused on the use of VR and AR in the construction apprenticeship process to minimise time off-site and increase safety and productivity. This naturally leads to it linking with several aspects of this review, with its use of VR and AR increasing the chances of making use of some of the benefits of each outlined above. The project's focus on these immersive learning methods, as well as its emphasis on developing their health and safety structure associates it with several outputs in the logic model:

- increased safety / injury rate reduction
- increased technical and creative skills

3.4.4 Mixed Reality Training Vehicle for Specialist Learning – Hire Association Europe

This project is focused on the development of a user-authoring immersive learning platform designed to strengthen the users connection to the training and improve their overall experience. This is similar to some of the other projects, where an increased emphasis on the immersive learning technology is emphasised in order to encourage better user engagement and ensure longer term knowledge retention. Examples of outcomes from the logic model that are associated with this include:

- increased retention in training and of skills / knowledge; and
- increased specific technical skills (relevant to project)

3.4.5 Construction Virtual Environment Resource Training – Construction Wales Innovation Centre

By aiming to produce outcomes that result in increased cost effectiveness (wood machining and paint spraying) as well as a working at height programme that aimed to improve health and safety in the workplace, it is clear that this project mirrors much of what has been referenced in this literature review. Specifically, it links to the opportunities raised around reducing costs as a result of the use of immersive learning and improving health and safety, with this directly running alongside outcomes from the logic model:

- increased safety / injury rate reduction
- increased problem-solving skills , including in potentially dangerous situations, locations or equipment

3.4.6 TunnelSkills Specialist Training Forum - TunnelSkills

The TunnelSkills project appears to align most closely with the concept of using immersive learning to develop understanding of very specific subject areas, with examples of this being work around access into shafts and tunnels under construction, sprayed concrete lining and the pit bottom. This was recognised in the opportunities section of the literature review, where the role of immersive learning in providing more tailored and more effective training for specific areas of construction was recognised. This is also mirrored in the logic model, as shown below:

- increased problem-solving skills, including in potentially dangerous situations, locations or equipment
- increased specific technical skills (relevant to project)

4. COMMISSION OVERVIEW AND IMPLEMENTATION STATUS

4.1 Introduction

This section provides an overview of the commission rationale and market failures which the CITB Immersive Learning Commission is seeking to address, as well as the aims and objectives of the six funded projects funded and their current status (as of July 2022).

4.2 Commission rationale / context

The commission was designed in 2019 (pre COVID 19) with the aim of addressing common skills and training issues through the development of sustainable immersive learning solutions.

The commission follows on from recommendations in the CITB report A New Reality: Immersive Learning in Construction³³ which found that immersive learning can help address these challenges in several ways:

- enhance the industry's appeal to 'digitally-native' audiences through future-focused technology
- increase the quality and coverage of training by providing experiences and environments that may not be possible via traditional methods, making students more 'work-ready'
- improve levels of collaboration and problem-solving tasks that stimulate more interrogation and knowledge retention
- reduce cost of delivery and optimise trainers' time by improving tutor / student ratios and freeing up time for more technical aspects

It also identified the following implementation challenges:

- limited awareness and understanding of what immersive technology is and what it can achieve
- among non-users, uncertainty over the benefits and return on investment of immersive learning
- lack of internal technology and content capabilities and limited links to experts in other sectors
- fragmented and non-standardised development and application across industry -resulting in duplication and variations in quality

The research led to a series of recommendations to encourage adoption of immersive technologies by the industry and CITB is responding to one of the key recommendations by funding a series of innovative immersive projects.

The impact of COVID-19 on the need and demand for the commission is detailed in section 4.4.

³³ CITB (2017) A New Reality: Immersive Learning in Construction

Issues and challenges faced by the construction sector

The sector faces many challenges across people and skills, finance, R+D, costs, and productivity. A 2016 CITB survey³⁴ of construction professionals found the key challenges facing sales and outputs in the sector were: insufficient demand; labour shortages; and access to a skilled workforce. This challenge is exacerbated by 'dysfunctional training' and an inadequate 'funding and delivery model' as identified in the 2016 Farmer Review of the UK Construction Labour Model.³⁵

Sector Demographic Profile and Skills - it is estimated that approximately 22% of the current UK workforce is aged between 50-60 and many will soon retire. Coupled with this, there are insufficient young people to replace them. Due to the poor image of construction, the industry is failing to successfully promote construction careers to school leavers and to attract a diverse range of people. Apprenticeship and levy statistics for March 2018 show that monthly apprenticeship starts were down by over 22%, while Brexit is also causing uncertainty in relation to skilled migrant labour.

Funding/ Finance - cash flow is a key issue for the construction sector due to various factors, the three important factors being: (1) the traditional lowest-cost procurement approach that leads to 'cut-throat' competition and low profit margins (2% on average); (2) long payment terms along with late payments from customers; and (3) fragmentation of the industry with many SMEs (including micro businesses) with financial fragility. Recently, the Brexit uncertainty has resulted in several project delays and cancellations leading to additional cash flow pressures.

Investment in R+D and in particular digital innovation - the construction sector has not invested significantly in R+D and digital innovation. Business enterprise R+D expenditure (BERD) levels in the construction sector are historically low, positioning the sector among the lowest in terms of digital innovation and IT investments compared to most other sectors (McKinsey, 2017).³⁶ However, the UK government's Industrial Strategy includes a target to raise investment on R&D to 2.4% of GDP by 2027. Moreover, industry drawdown of R+D tax relief in engineering and construction relative to all claims made is negligible, as of a total £1.75 billion offered to SME's in the UK through the R+D Tax Credits Scheme, only 324 construction businesses have taken advantage of the scheme (the amount claimed is undefined, however likely to be a very small amount). This is symptomatic of a lack of interest in, or incentive to, consider modernisation in the industry despite meaningful tax offsets being offered (data suggests construction R+D is running in the order of only 0.1% of output).

Costs / Productivity - the sector has had an ongoing emphasis on decreasing costs / reducing waste and inefficiencies with varying degrees of success. The Construction 2025 Industrial Strategy³⁷ has targets of 50% faster delivery, 33% lower costs and 50% lower emissions. However, poor productivity is regularly identified as a key failure in the UK construction sector as encountered in the Farmer Review of the UK Construction Labour Model³⁸; the CIOB's 'Productivity in Construction' report³⁹; the RICS 'framework to enhance construction productivity involving international professionals and contractors'⁴⁰; the Constructing Excellence's 'Unlocking productivity' report⁴¹; and the CITB's report on 'Skills and Training in the Construction Industry 2016'.⁴² Findings from these reports indicate the barriers to improving productivity are deep-rooted and require fundamental change. Government has pledged £170 million in the 'Transforming Construction' programme with industry match-funding through £250 million

³⁴ CITB (2016) Skills and Training in the Construction Industry 2016

³⁵ Farmer, Mark (2016) The Farmer Review of the UK Construction Labour Model

³⁶ McKinsey Global Institute (2017) Reinventing Construction: A Route To Higher Productivity

³⁷ HM Government (2013) Construction 2025

³⁸ Farmer, Mark (2016) The Farmer Review of the UK Construction Labour Model

³⁹ CIOB (2016) Productivity in Construction

⁴⁰ RICS (2016) Framework to enhance construction productivity involving international professionals and contractors

⁴¹ Constructing Excellence (2016) Unlocking Productivity

⁴² CITB (2016) Skills and Training in the Construction Industry 2016

investment. Innovate UK and the UK Government Department of Business, Energy and Industrial Strategy have also formed a partnership to deliver the next phase of digitisation in the construction sector through the 'Digital Built Britain' programme which will develop BIM, data analytics and smart systems technologies. This demonstrates the CITB's Immersive Learning commission and its established aim and objectives are fully aligned with all these reports' findings and the overall Government's direction.

Supply Chain - the construction sector depends heavily on subcontractors as 99.8% of firms are small or micro businesses and, of those, some 86% employ no more than one person.⁴³ According to a UK Parliament report "*there is no 'one construction' sector but a range of specialist subsectors. These can be very different from each other and can also be characterised by different supply chain relationships, at times driven by the business models of the client organisation*". These micro and small organisations often find it notoriously difficult to find the time and funds to invest in new ways of working and training / development. Hence, it is important to understand the reach and impact of the Commission's projects and how this could be affected by the characteristics of different supply chains and business models for projects that are sector specific (i.e., tunnelling, nuclear).

4.3 Commission summary

In total £3,236,929.00⁴⁴ was initially allocated by CITB across seven (now six) interventions which aimed to increase the uptake and adoption of immersive learning in the construction industry. Specifically, they aimed to⁴⁵:

- apply immersive learning in innovative ways that demonstrate sustainable and scalable impact in an area with significant potential benefits;
- test, pilot and implement immersive learning with beneficiary groups employed in construction or who have the potential to become so, that stand to make significant gain from its application; and
- promote awareness and familiarity with the opportunities for Immersive Learning among wider industry, to increase the potential for wider uptake, by showcasing funded solutions through events, forums and networks.

The following table provides an overview of each funded project and their planned key outputs:

⁴³ UK Parliament (2017) 'Construction and Related Engineering Sector Report'

⁴⁴ This includes allocated funding for the Manufacturing Technology Centre / Advanced Manufacturing Research Centre project which was not continued when the commission re-started following a pause due to the impact of Covid-19 on delivery.

Excluding this project, funding allocation totals £2,585,929.00

⁴⁵ CITB (2019) Immersive Learning Commission Launch Event Slides

Table 4: Key project outputs

Project: Improving Behavioural Induction for Highways

Lead partner: BAM Nuttall Ltd

The project has 3 components:

- Instructor-led immersive classroom learning - classroom learning supplemented with immersive content including augmented reality (AR) enabled tablet applications, interactive quizzes and educational games. Intended to create a three-way learning experience with learning from immersive content aligned to the instructor narrative
- Takeaway App - containing induction information that can be accessed by programme attendees for future reference whilst on site
- Promotional VR Game - promotional virtual reality (VR) game operable on commercial hardware for use at industry and recruitment events as an innovative promotional tool for immersive training

Outputs

- Networking of learner apps controlled by a “hub” app which the instructor can use to monitor learners in real time
- Increased uptake of non-active English speakers undertaking inductions in native language
- Increased ability to measure learner performance through data analytics from app
- Reduced learning hours, increased class sizes and increased learning retention for site induction
- Improved access to site safety, behaviour and culture information in native language
- Uptake of site induction programme at other Highways sites
- Increased awareness of cultural and behaviours values in modern construction sites
- Increased appeal of construction sector through showcasing of new

Project: TunnelSkills

Lead partner: TunnelSkills Specialist Training Forum

The project includes 4 components:

- Classroom Tablet - instructor led immersive learning content and assessment delivered in classroom using discussion and tablet devices
- Classroom Virtual Reality (VR) – instructor led immersive VR learning Content delivered in classroom using Oculus Go standalone VR headsets
- Promotional VR Game – VR game for promotion and outreach that repackages classroom content
- Takeaway App – takeaway / downloadable app containing key take away content for future exploration and reference

Outputs

- Test and pilot 8 learning experiences with 300 – 400 existing tunnelling employees and learners (100 logged as accessing the web-based resources by Google Analytics)
- Test and pilot 8 learning experiences with 26 apprentices
- Deliver 50 experiences at careers and employer engagement events
- Final project report
- Case study

Project: Immersive Learning for Construction - Plymouth

Lead partner: City College Plymouth

The project involves the development of a virtual 4-bedroom house and building site from which a range of learning is undertaken.

Behavioural safety training modules are developed at each stage of construction, for example: plant and equipment hazards in initial stages; WAH in the final stages; electrical and fire hazards in a completed build. Modules map to OCN Level 1 Health and Safety course and multi-purpose across disciplines. The project expands the capacity and capability of immersive learning by promoting virtual reality (VR) in construction at careers events, as well as delivering a programme of upskilling college staff and local employers in how to adopt and embed immersive learning.

Outputs

- Detailed interactive house digital asset for learning interventions
- VR health and safety modules aligned to occupations, mapped to L1OCN
- 180 L1 and 2 learners / apprentices / workers receive health and safety training modules
- VR bite-size competency modules for technical / supervisory / management competencies
- 26 supervisors / managers undertake blended behavioural learning using VR twinned with real environments
- 34 careers and employer engagement events
- Modules piloted with 32 delegates (28 tutors and 4 construction employer trainers)
- Pilot training with 15 in-house tutors and 15 employer related trainers for longevity of the programme

Project: Transforming Construction Trade Apprenticeships

Lead partner: Bridgwater and Taunton College

The project supports colleges in delivering the apprenticeship requirement for 20% off-site learning for Steel Fixing Drawing and Shape Codes. It uses AR to enhance the acquisition of skills and competencies, reinforced on site using a remote access collaborative VR classroom. Apprentices use immersive learning headwear in college to enhance real-world learning. They are given a low-cost mobile VR headset that they will take to site that will be worn off-site at scheduled times to refresh skills in a collaborative virtual classroom shared with apprentices and tutor.

Outputs

- Real-world training area to replicate competencies and tasks, overlaid with AR assets in Steel Fixing Drawing and Shape Codes
- Virtual classroom 3D environment (that learners can collaborate in)
- VR module for remote delivery in VR classroom, using untethered headsets
- Delivered to: 32 construction steel fixer apprentices
- Talkout VR to:
 - Produce a video on required Pile Cap build sequence and safety measures with BTC Specialist Trainers
 - Incorporate Rebar shape codes, videos and 3D BIM build models into augmented reality platform
 - Develop final augmented reality package for Pile Cap to build and produce app file for download onto CSIC tablets
 - Notify BTW of app availability
- BTC to:
 - Download and install AR app
 - Test app and ensure it is working prior to apprentices
 - Run a pilot with a group of new apprentice to evaluate how this technology supports and / or enhances the learning experience
 - Produce initial evaluation report with recommendations for revised specification

Project: Mixed Reality Training Vehicle for Specialist Learning

Lead partner: Hire Association Europe

The project develops a web-based content creation platform and community space that allows users to generate their own learning experiences for virtual and augmented reality. The system uses a drag and drop interface and includes a learner management system that allows learning experiences to be tracked, monitored and quality assured. The platform hosts VR content developed by HAE from other projects. Content is accessible in 3D via a computer screen, and in PDF. The platform is hosted by HAE, made available to industry and funded by a low-cost pricing model.

Outputs:

- Content creation VR / AR platform
- Modules: Mental Health at Work; Environment and sustainability; Dust / Silica / Asbestos; Banksman / Traffic Marshalling; Introduction to Hire
- Pilot with 2192 industry employees and learners
- Delivered to: 850 NVQ candidates; 52 SUP candidates; 40 Trailblazer candidates (it has been agreed that while CITB would like to achieve as many of the beneficiary numbers from the target groups as possible, if this is not viable would also accept other relevant beneficiaries (e.g., apprenticeship candidates; relevant candidates from the existing workforce; and on site experience hub candidates who become employment and site ready etc

Project: Construction Virtual Environment Resource Training (CONVERT)

Lead partner: Construction Wales Innovation Centre (CWIC)

The project delivers a GB-wide physical infrastructure that delivers a sustainable and scalable immersive learning solution through six delivery hubs across three nations. The project delivers learning interventions through 4 work-streams supported by a train-the-trainer programme to build industry capacity and capability to deliver immersive learning, as well as development of a be-spoke learner management system

Outputs

- 6 regional delivery hubs equipped to deliver content to 2,440 learners across 3 nations from 50 employers
- Training 120 trainers to work across 414 training events
- Engaging 813 individuals across 96 engagement events
- Learner performance management online framework / portal
- Work-streams:
 - Drone piloting and surveying x 4 VR modules
 - Wood machining / spraying x 4 AR modules
 - WAH / scaffolding x 4 VR modules
 - Building deconstruction for induction x 10 VR/BIM modules
- Final report

4.4 Contextual Note: Impact of COVID-19

The COVID-19 pandemic impacted the projects to different extents. The current status (as at July 2022) of each project is:

Table 5: Project Status

Project	Start Date	End date	Status
Improving Behavioural Induction for Highways (BAM Nuttall Ltd)	September 2018	September 2021	The project was completed in September 2020 and was successful in delivering many of the key outputs as evidenced by the end of project report produced by BAM Nuttall. However, as no specific output data was provided for the project, assessment of progress against targets is based solely on the end of project report.
TunnelSkills (TunnelSkills Specialist Training Forum)	1 st February 2019	December 2022	The project is on track and has been successful in meeting all of the to-date targets. In many cases the output targets have been surpassed.
Immersive Learning for Construction – Plymouth (City College Plymouth)	1 st February 2019	31 st March 2022	The project was completed in March 2022 and was mixed in its delivery of outputs. However, as no specific output data was provided for the project, the assessment of progress against targets is based solely on the end of project report produced by City College Plymouth.
Transforming Construction Trade Apprenticeships (Bridgwater and Taunton College)	1 st February 2019	31 st January 2022	No evidence or data has been provided for this project therefore it is not possible to comment on project progress.
Increasing Capacity and Capability to Deliver Immersive Learning in the Construction Industry (Manufacturing Technology Centre / Advanced Manufacturing Research Centre)	Project closed		
Mixed Reality Training Vehicle for Specialist Learning (Hire Association Europe)	1 st May 2019	31 st March 2023	The project is ongoing and has successfully delivered the 6 main modules scheduled however it is underperforming in the rest of the target outputs.
Construction Virtual Environment Resource Training (CONVERT) (Construction Wales Innovation Centre (CWIC))	1 st May 2019	31 st October 2022	A number of the project's targets have been met but an inability to reach overall targets highlight's the project's mixed performance.

Source: CITB Immersive Learning Project Targets Summary (June 2022)

A seventh project 'Increasing Capacity and Capability to Deliver Immersive Learning in the Construction Industry' was originally led by Manufacturing Technology Centre and the Advanced Manufacturing

Research Centre to create a standardised, sustainable model for industry to develop and deliver their own immersive learning content through a user-content authoring platform. However due to internal changes and lack of resources, MTC requested that the project be closed. This impacted the AMRC project as it meant that the original outcomes could not be received. AMRC submitted an alternative proposal to the CITB strategy team however on review this was not approved.

Impact of Covid on need / demand

COVID-19 had a substantial impact on the demand or need for the projects. Headsets could not be used due to the need for social distancing. COVID-19 resulted in many of the education institutions, through which the projects were intended to be delivered, closing for long periods of time. Demand for external training providers decreased during COVID-19, as institutions were far less open to inviting external individuals onto their sites / into their schools or colleges due to increased risk of infection and as a result of the aforementioned social distancing constraints.

5. PERFORMANCE – OUTPUTS, OUTCOMES AND IMPACTS

5.1 Introduction

This section reports on performance against targets and the direct and indirect impacts delivered by projects to date.

5.2 Performance Against Targets per Project

The following sub sections analyse project performance against their targets / KPIs agreed with CITB based on the latest quarterly monitoring report submitted by the project to CITB. For those projects that are still ongoing, pro-rata/ to-date targets are included in order to ensure that each project is assessed fairly relative to its phase of completion. The level and detail of data available varies per project as not all projects used a standard, structured monitoring report template that linked back to their agreed targets and therefore it was not possible to comment on all targets for some projects. Full detail on performance against targets is in appendix A.

5.2.1 Improving Behavioural Induction for Highways (Lead Partner: BAM Nuttall Ltd; September 2018 – September 2021)

The BAM Nuttall project was completed in September 2020, however no specific output / monitoring data was provided for this project, and the analysis of performance against targets is based solely on the end of project report submitted to CITB by BAM Nuttall.

The project received £244,309 in CITB funding plus £105,000 in matched funding (£349,309 in total). Of this, **£244,309** has been claimed from CITB.

Evidence of output delivery for this project is inconsistent, meaning analysis of the project's success is difficult to determine as many key outputs were not measured. However, those that were measured show the project's success in key areas. In particular, the end of project report suggests that classroom time reduced, with the introduction of the immersive learning platform reducing this by 50% as well as a reduction in administration time. This, as well as other elements of the project that were recorded as 'successfully delivered', suggests success in providing key learning platforms that could contribute to improvement in the quality of training as well as the development of key technical skills.

5.2.2 TunnelSkills (Lead Partner: TunnelSkills Specialist Training Forum; February 2019 – December 2022)

The TunnelSkills project is ongoing and due to complete in March 2023. The project received £249,903 in CITB funding plus £110,600 in matched funding (£360,503 in total). Of this, **£239,108** has been claimed from CITB and 682 (26 apprentices and 656 current tunnellers / learners experiencing learning pilot) have participated in the project.

The TunnelSkills project has been successful in meeting both its to-date and overall targets. All adjusted targets have been surpassed, with 1 of the overall output targets (testing and piloting learning experiences with 300-400 existing tunnelling employees and learners) already exceeded.

This performance suggests that the project has succeeded in delivering the necessary outputs to contribute towards the successful delivery of project outcomes. This is shown by the delivery of tunnelling-specific immersive learning scenarios to contribute to the development of specific technical

skills. This is supported by outcome analysis in section 5.3, where 96% of TunnelSkills beneficiaries who completed the survey felt they had achieved learning outcomes focused on skills development.

5.2.3 Immersive Learning for Construction - Plymouth (Lead Partner: City College Plymouth; February 2019 – March 2022)

The City College Plymouth project was completed in March 2022, however no specific output / monitoring data was provided for the evaluation and the analysis of performance against targets is based solely on the end of project report submitted to CITB by City College Plymouth.

The project has received £270,567 in CITB funding plus £109,396 in matched funding (£379,936). Of this, **£270,567** has been claimed from CITB and 1,444 participants have taken part in the project.

The lack of data means it is difficult to provide an overall assessment of performance. However areas of success include the delivery of a virtual house model as well as health and safety modules that aim to improve health and safety understanding in the industry and provide a more engaging model of training.

5.2.4 Transforming Construction Trade Apprenticeships (Lead Partner: Bridgwater and Taunton College; February 2019 – January 2022)

No evidence or data was provided by Bridgwater and Taunton College for the Transforming Construction Trade Apprenticeships project therefore it was not possible to assess its performance against targets.

The project received £181,176 in CITB funding plus £63,194 in matched funding (£244,370 in total). Of this, **£157,476** has been claimed from CITB.

5.2.5 Mixed Reality Training Vehicle for Specialist Learning (Lead Partner: Hire Association Europe; May 2019 – September 2022)

The most recent output data provided for this project is from November 2021, therefore it is possible the performance assessed may have progressed further however the project was not able to provide up to date details at this time.

The project has received £225,960 in CITB funding plus £95,250 in matched funding (£321,210 in total). Of this, **£191,804** has been claimed from CITB and there have been 43 recorded beneficiaries to date.

The evidence in appendix A indicates the project has delivered 6 modules as scheduled as well as another 8, however were unable to deliver the training to the numbers expected due to restrictions caused by the pandemic (sharing headsets, venue closures, etc.).

5.2.6 Construction Virtual Environment Resource Training (CONVERT) (Lead Partner: Construction Wales Innovation Centre (CWIC); May 2019 – October 2022)

The project has received £1,414,014 in CITB funding and £606,004 in matched funding (£2,020,018 in total). Of this, **£1,278,707** has been claimed from CITB and there have been: 735 training event attendees, 735 engagement event attendees, 660 trainees completing training, 54 trainers trained, 39 employers engaged.

Of the pro-rata targets, only 1 has been exceeded (training programmes / modules developed) and only 2 have achieved over 40% of their overall target metric despite the project now being 85% completed against its intended completion date.

Feedback from the project lead suggests this is mainly due to the impact of COVID-19 on project delivery as well as changes in personal and partners. However if this trajectory continues and the number of trainees does not increase, it will limit the project's ability to deliver the intended outcomes. This will be further explored in the final report.

5.3 Outcomes Achieved

Of the six projects at min two of these have significantly lower beneficiaries than expected (for two others this is unclear due to incomplete data). This has limited the impact of the overall commission to date. However a number of projects have evidence of new training delivering increased health and safety knowledge, technical skills and supporting behavioural change. The following sections detail the reported outcomes to date.

5.3.1 Increased skills

TunnelSkills beneficiary survey responses (n= 455⁴⁶) across the nine different immersive learning experiences indicate the majority (96%) achieved their learning outcomes had been achieved. The learning experiences include aspects such as responding to emergencies, hand mining and pipe jacking. While the survey does not detail the exact technical skills beneficiaries gained, the overwhelmingly positive feedback suggests that trainees did gain specific, new technical and safety skills.

Similarly, 93% of CONVERT trainees reported achieving the learning objectives for improved skills across the following areas⁴⁷:

- working at height;
- virtual built environment;
- using drones;
- paint spraying; and
- wood working.

Apprentices who used training developed for Transforming Construction Trade Apprenticeships (Bridgewater & Taunton College) experienced improvements in a number of technical skills related to steel fixing⁴⁸:

- interpreting and working to drawings;
- using specifications on different platforms;
- manual positioning and fixing; and
- improved logical thinking and behaviour in sequential tasks.

Limited or no evidence of the specific technical skills developed was submitted by the other three projects.

5.3.2 Increased retention in training and of skills / knowledge

The immersive learning projects have the potential to improve retention of skills and knowledge as some developed apps that users can download and use after the training or induction. This has the potential to improve retention if students or staff engage with the apps to do refreshes as needed. At present there is no evidence of uptake of these apps - this will be included in the final report where evidence is available.

⁴⁶ Of the 77 trainees / learners, many have accessed multiple of the nine different Immersive Learning experiences – this has resulted in a total of 455 responses to the question ‘Has the training helped you to achieve the following Learning Objectives?’

⁴⁷ Beneficiary survey.

⁴⁸ Project lead interview.

In addition:

- one project developed training content in four different languages thereby increasing accessibility of training for those who do not speak English.⁴⁹ Where possible, uptake of this will be explored in the final report
- trainees from another project highlighted that using virtual and augmented reality through headsets and tablets made it "*fun and easy*" to learn and "*far more memorable than a PowerPoint session.*"⁵⁰

5.3.3 Increased safety

Training materials have improved the safety awareness of trainees. City College Plymouth asked over 500 individuals⁵¹ who used the training to indicate how helpful they found the content in improving their health and safety behaviour. All the trainees found the training to be at least "somewhat helpful". In some sessions, all the trainees reported finding the training "extremely helpful".

They have also reduced the need for construction site visits by apprentices or school pupils, reducing their exposure to hazardous environments: "*there's no major health and safety issues when you're on a virtual machine*" (project partner).

5.3.4 Improved quality of training (e.g., opportunities to experience greater range of scenarios; undertake problem solving; enable greater experimentation)

Apprentices and construction staff who used the training have a realistic understanding of the work that they are likely to conduct on site:

"It gives a much better insight into reality of life in a tunnel. Don't believe any other method would be able to give the same level of immersion" (TunnelSkills trainee)

They acquired this knowledge in a safe environment with few costs, as there was no need for the safety equipment otherwise required on actual construction sites. For some training material, students were able to conduct their learning at their own pace rather than rushing through content.

⁴⁹ Improving Behavioural Induction for Highways Final Report.

⁵⁰ TunnelSkills beneficiary survey.

⁵¹ City College Plymouth Final Report; it is not clear how many of the trainees were school pupils, college students, or construction employees.

5.4 Direct Impacts per Project

The table below provides an overview of how each project is achieving desired commission impacts as specified in the logic model.

Table 6: Direct impact per project

Project Name	Direct Impacts (linked to logic model)				
	Increased awareness of immersive learning	Employers more willing to use immersive technology	Students empowered to strategise and make their own decisions	Increased efficiencies	More effective learning at a lower cost
Improving Behavioural Induction for Highways	No evidence available.	No evidence available.	No evidence available.	Pass rate of training is 100%, with refresher app available for use by the trainees. The training is transferable to other construction sites.	Reduced time for induction training from 3 to 1.5 hours, resulting in time and costs saved. Tablets automatically record pass rates, which reduces administration time for trainers.
TunnelSkills	Employers have understood the potential of immersive learning and use it to train and engage apprentices. Trainees are more aware of immersive learning training approaches.	Project partners used the learning content for community outreach and with apprentices.	No evidence available.	The need for specialist on-site training is reduced as apprentices who use the immersive learning content are able to decide whether they are interested in tunnelling or not.	The training helps apprentices to identify whether or not they are interested in tunnelling. Using the immersive learning technology saves costs associated with site visits and reduces safety hazards.
Immersive Learning for Construction - Plymouth⁵²	College teaching staff have increased their awareness and use of immersive learning in courses.	No evidence available.	There is anecdotal evidence that young people who engaged at school or college fairs	No evidence available.	No evidence available.

⁵² The project's beneficiary survey and report do not discuss impacts.

Project Name	Direct Impacts (linked to logic model)				
	Increased awareness of immersive learning	Employers more willing to use immersive technology	Students empowered to strategise and make their own decisions	Increased efficiencies	More effective learning at a lower cost
			have chosen to enter construction jobs.		
Transforming Construction Trade Apprenticeships	No evidence available.	On building sites, many construction site drawings are now done with tablets.	Apprentices have a better understanding of the logical sequence of steel fixing work and conduct tasks accordingly.	The project lead felt that apprentices in the workforce can now coach others and build the knowledge base within their companies as a result of the training.	No evidence available.
Mixed Reality Training Vehicle for Specialist Learning	Several student engagement events and careers shows demonstrated construction jobs to interested young people through the app. Making their learning app available on google play and the apple app store has made it available on hundreds of thousands of devices.	Project leads felt they had been successful in achieving their aim of making the platform accessible to non-technologists	No evidence available.	The app developed can be used anywhere, improving accessibility to training.	No evidence available.
Construction Virtual Environment Resource Training (CONVERT)	Partners are exploring more virtual learning opportunities for their college courses.	Target audience is mainly college students and pupils.	Students can complete the training materials at their own pace.	No evidence available.	No evidence available.

Source: TunnelSkills beneficiary survey; project lead and project partner interviews; final project reports.

Based on interviews with leads and partners of all projects and final reports and data from two projects, the **main impacts** reported are:

- a reduction in costs of training;
- an increase in employers' ability to engage with communities and apprentices; and
- employers are more aware of and willing to use immersive learning technologies.

TunnelSkills, Transforming Construction Trade Apprenticeships, and CONVERT learning materials have been used more as an engagement tool for young people in education or local communities and less as a means to train staff on site. This is because on-site training requirements change over time, but the virtual content can continue to be used to raise awareness and interest among young people even if unchanged: *“the more I think about it, the more I think that the main use is recruitment and getting people into tunnelling. The thing we will struggle with is getting it used as a health and safety training aid”* (project partner). Updating training content is expensive. In addition, each construction site has to have site-specific inductions, which are difficult to do in standard immersive learning material: *“good for some basics on projects for inductions. Some of the materials are good for schools and engagement programmes”* (project partner). Finally, partners found that existing, experienced staff are sometimes hesitant to use virtual or augmented reality training.⁵³

Nonetheless, learning modules developed by TunnelSkills and Improving Behavioural Induction for Highways have been successfully used to train existing staff. The skills and knowledge outcomes achieved are described in section 5.3. Apprentices at Bridgewater & Taunton College have also reported improved technical skills from using Transforming Construction Trade Apprenticeships training content.

The projects appear to be effective at increasing interest of people in education in careers in the construction industry. For example, 70% of the TunnelSkills trainees who were not already employed in construction (the majority is not in construction, but in education), said that their experience of the training motivated them to investigate a career in construction.

5.5 Indirect Impacts

Indirect impacts relate to an increased awareness of immersive learning and its uses, and to improved health and safety knowledge, outside of those directly training.

5.5.1 Indirect beneficiary survey

The survey of indirect beneficiaries (n = 22 / response rate = 71%) was designed by RSM UK Consulting in collaboration with CITB to collect evidence against the key evaluation questions and logic model metrics. Online survey links were distributed via the lead project partner.

Who is an indirect beneficiary?

Indirect beneficiaries of the projects included organisations from the transport and various construction sectors, charities and educational organisations:

- 2 of the 22 surveyed are from the transport sector including commercial and housing development, and the utilities sector
- 2 of the 22 surveyed come from the woodworking and joinery manufacturing industry
- 3 of the 22 surveyed are part of the building construction sector
- 3 of the 22 respondents provide architectural, engineering activities, and related technical consultancy services
- 6 of the 22 surveyed organisations are civil engineers

⁵³ CITB Immersive Learning Event (July 2022).

- 6 of the 22 surveyed come from other sectors including further and higher education in the construction, civil engineering, architectural technology sectors, as well as charities and local authorities
- All 22 respondents completed either TunnelSkills or Convert training

Outcomes for indirect beneficiaries

All 22 respondents to the indirect beneficiary survey benefitted from the project they were involved in. Respondents increased their understanding of immersive learning technologies and how these can be used in the construction sector. Specific outcomes indirect beneficiaries achieved include:

- increasing **safety and removing risks of injuries**, allowing students to practice using machinery and drones in a safe environment;
- **familiarising** staff (both office and site based) with the use of immersive learning hardware;
- increased **understanding** of engineering and tunnelling and of 'What if' scenarios for Health & Safety learning, and access to hard-to-reach portable joinery spraying training;
- improved quality of training and students' engagement;
- apprentices developed personal skills and experienced a **greater range of scenarios** in their learning, with access to otherwise dangerous training situations (e.g., tunnelling work or working from height); and
- increase in collaborative working and clearer communication across the sector

The value of immersive learning training reported is also illustrated in the qualitative feedback provided:

“It creates a very realistic, but safe environment to learn. The performance summary can help demonstrate gradual improvement. It is likely to give new operators confidence that they can move on to operate real-life equivalent machinery safely and efficiently.” – Indirect beneficiary

“It would be too risky to allow students to fly drones without first trying the virtual training. It is also useful for students to learn how to erect scaffolding safely to understand how to manage people who do but it would not be advisable or practical to do this in reality and the virtual training is excellent for this.” – Indirect beneficiary

“It is possible to create a realistic emergency response situation in a darkened environment (e.g., training room or shipping containers) with added smoke etc - but the Immersive Learning resources via the headsets makes this environment more accessible and more 'immediate' with the added time pressure in the 'game-like' emergency response app.” – Indirect beneficiary

Impacts for indirect beneficiaries

Indirect beneficiaries also suggested that immersive learning was effective in raising awareness of and promoting careers in construction among young people. For instance, one respondent noted:

“The opportunity is evident - our members are progressive and are used to making significant financial investment in the right technology/machinery. Having immersive learning opportunities will better prepare future operators to gain the skill and confidence needed to progress to real machines. Young people are more comfortable with these new technologies and we intend developing further resources that include elements of interactivity and VR.” – Indirect beneficiary

Lessons learned / future use case of technology

Overall, 19 of the indirect beneficiary respondents stated they valued the immersive learning approach as an alternative to real-life situational training, however 2 of them indicated that this would be a complement rather than an alternative to real-life training.

Indirect beneficiaries were also asked if they experienced barriers to the adoption of immersive learning technologies, specifically:

- cost for software, licensing, equipment, or infrastructure, as stated by (stated by 11 of 16 respondents to this question)
- a lack of understanding of what immersive technology and learning is a barrier to adoption (stated by 6 of 16 respondents)
- contracts with other existing training provider (stated by 3 of 16 respondents)
- unconvinced of the value of immersive learning (stated by 2 of 16 respondents)

5.6 Enablers and Barriers

Project leads and partners discussed a number of enablers and barriers to date:

Enablers

- The price of technology is falling: this makes it easier for companies to afford the use of immersive learning.
- CITB's flexible approach during and after COVID-19 enabled projects to adapt their approach to demand and need.
- Technological knowledge of project partners who developed applications and content was important in translating lead and other project partner's needs into well designed immersive learning outputs.
- Dedicated helplines for troubleshooting, helped partners to address hardware issues relatively smoothly.
- Variety of immersive learning types, from VR to AR, using headsets, tablets and other specialist hardware helped trainees engage and stay interested in the content.

Barriers

- COVID-19 lockdowns and social distancing rules meant that projects had to pause and then limit the numbers of trainees in a room. In addition, hardware such as VR headsets and tablets had to be properly cleaned before the next trainee could use it.
- Some hardware, such as wood working or paint spraying machinery, is expensive and difficult to transport. This limited the number of training partners who could use some of CONVERT's relevant training material.
- Employers and training providers who partnered with the project leads did not always have staff with the right technological know-how to use hardware. This meant that project leads needed to invest time to train the trainers.

6. VALUE FOR MONEY / ADDITIONALITY

6.1 Introduction

The Value for Money (VfM) assessment aims to identify whether there has been an optimal, efficient or effective allocation of funding and considers whether the funding provided by the CITB was successful in deriving value for the taxpayer. Following Green Book HMT guidance, a VfM should try where possible to quantify the costs and benefits of the commission to produce appropriate metrics such as: net present value to society of all social, economic and environmental benefits, benefit cost ratios, or Return on Investment (ROIs).

6.2 Value for Money

There are several transmission channels through which value would be derived as seen in the logic model (figure 2). These include increased adoption of immersive technologies as employers become more aware of supportive technological advancements, leading to more effective learning at a lower cost and less time (ie increased efficiency).

To assess whether these benefits have been experienced, data is required on activities post participation. As the Commission is still ongoing, this will be explored in more detail in the final report and include:

- number of employees trained
- reallocation of time dedicated to on-site production of construction services away from training. (cost saving, revenue generation)
 - more efficient use of on-site production of construction services
- improved future training and subsequent construction industry attractiveness as a place of work
- wider benefits experienced such as improvements in infrastructure development

As the immersive learning commission is still ongoing, the benefits are likely to take time to be realised.

The following table outlines the CITB and match funding provided as well as spend to date, including staffing costs associated with monitoring and governance.

Table 7: Funding schedules (Cost of the Immersive Learning Commission)⁵⁴

Project Name	Total CITB Funding ⁵⁵	Match Funding	CITB Spend (to date as of 12/07/2022)	Remaining CITB Spend
Improving Behavioural Induction for Highways	£244,309	£105,000	£244,309	£0.00
TunnelSkills	£249,903	£110,600	£239,108	£10,795
Immersive Learning for Construction - Plymouth	£270,567	£109,396	£270,567	£0.00
Transforming Construction Trade Apprenticeships	£181,176	£63,194	£157,476	£23,700
Mixed Reality Training Vehicle for Specialist Learning	£225,960	£95,250	£191,804	£34,156
Construction Virtual Environment Resource Training (CONVERT)	£1,414,014	£606,004	£1,278,707	£135,307
Total	£2,585,929	£1,089,444	£2,381,971	£203,958

In addition to the table above, the closed project⁵⁶ 'Increasing Capacity and Capability to Deliver Immersive Learning in the Construction Industry' (Manufacturing Technology Centre / Advanced Manufacturing Research Centre) had originally total planned funding of £651,000, with a total amount paid in funding prior to the funding being withdrawn of £373,686⁵⁷.

It has not been possible to calculate a cost per participant robustly and consistently as for some projects the total number of participants is not yet known. This will be completed in the final report if final participant numbers can be provided by each project lead. However cost per participant is only one measure and therefore the final report will assess the outcomes achieved against funding provided as per the outcome metrics in the logic model.

⁵⁴ Financial information provided by CITB to RSM UK Consulting (December 2022)

⁵⁵ The total funding may vary from the originally planned funding as there are variations due to some projects being withdrawn and scale of projects and timescales being affected.

⁵⁶ See section 4.4 'Contextual Note: Impact of COVID-19' in the report for details.

⁵⁷ Financial information provided by CITB to RSM UK Consulting (December 2022)

7. CONCLUSIONS AND RECOMMENDED NEXT STEPS

7.1 Introduction

This section outlines key findings to date based on the evidence collected and next steps for the remainder of the commission.

7.2 Key Findings

7.2.1 Delivery and performance

- **performance against key output targets is mixed** - TunnelSkills in particular has performed very well, meeting or exceeding all targets expected to date (as of July 2022). However, all other projects have either been unsuccessful in delivering on specific output targets or have not provided evidence to show they have been achieved.
- **there were inconsistencies in output performance reporting throughout** - with the exception of TunnelSkills and CONVERT, no project was able to provide a detailed and up-to-date evidence of performance against output targets. This makes assessing performance of the overall commission difficult when key areas of projects are not assessed entirely.
- **COVID-19 is a factor that impacted delivery and the achievement of outputs** - the pandemic forced most projects to pause and / or redesign their delivery model which may have reduced momentum in meeting output targets. When lockdowns eased, employers were also less concerned with training and more with winning and delivering work.
- **notwithstanding mixed performance, almost all projects have achieved success in specific target areas** - 5 of the 6 projects provided evidence of successful delivery of immersive learning modules or training programmes. This has contributed to some of the observed outcomes and impacts such as improved health and safety skills and increased retention of skills / knowledge.

7.2.2 Achievement of outcomes

COVID-19 impacted on the ability of projects to delivery their activities as planned. Nonetheless, there is **some evidence** suggesting the projects achieved a variety of expected outcomes. These mainly relate to apprentices and school pupils developing a better understanding of what construction work entails in a safe environment, and existing staff developing their health and safety related knowledge. Three projects achieved improvements in specific technical skills for apprentices using the training, such as the ability to interpret and follow technical drawings.

Some projects developed applications that trainees can download and consult after the training, potentially **increasing the likelihood of retention and behaviour change**. The interactive nature of the training courses, using headsets and tablets instead of PowerPoint, was positively received by trainees and suggested this approach helps them learn and retain the training material.

Evidence to date suggests the some of the intended outcomes from the commission has been achieved:

- apply immersive learning in innovative ways that demonstrate sustainable and scalable impact in an area with significant potential benefits – each of the six projects have applied immersive in different, innovative ways however there is not yet evidence of sustainable and scalable impacts to increase the uptake and adoption of immersive learning in the construction industry

- test, pilot and implement immersive learning with beneficiary groups employed in construction or who have the potential to become so, that stand to make significant gain from its application – five of the six projects have engaged with their target beneficiary groups to test, pilot and deliver training / learning modules (no evidence was available for the Transforming Construction Trade Apprenticeships project)
- promote awareness and familiarity with the opportunities for immersive learning among wider industry, to increase the potential for wider uptake, by showcasing funded solutions through events, forums and networks – there is evidence that two of the six projects have delivered training and careers / employer engagement events

In addition, in July 2022 CITB asked for any evidence on whether the commission has had a positive influence on one or more of the following points:

- bringing more people into industry
- training capacity (e.g., if fewer people are needed to do some of the teaching)
- the training assessment process

While it is not possible to provide insight at this stage of the evaluation, these themes will be explored further (where relevant) for the final report.

7.2.3 Achievement of direct and indirect impacts

The **main direct impacts** include:

- **increased efficiencies** - for example, qualitative feedback from project leads suggests that using immersive learning in colleges makes it easier for those who have never been on site to experience the environment and hazards. This reduces the need for specialist on-site induction training as only those with an interest in the sector are likely to visit construction sites. Those who used the training for on-site induction of construction staff reported a 100% pass rate for the trainees.
- **more effective learning at lower cost** – for example, the use of tablets in on-site induction reduces the time required from trainers and thereby reduces costs. For example the BAM end of project report notes:

““This project has taken the challenge of traditional time-intrusive and costly inductions and utilised technology to promote learning in more engaging ways. It's more inclusive with the option to learn in different languages and the games and tests are fun but allow facilitators to check that attendees are learning – this is essential to health and safety on site. It's received great feedback from users and proved to have big time and cost savings.””

“This method of induction has reduced the time spent in induction from 3 hours to around 1.5 hours. A large saving in time and money”

- an **increased awareness** among employers and trainees and **increased** willingness to use immersive technology for either training or engagement purposes - for example, employers use TunnelSkills immersive learning content to engage apprentices.

Other less commonly reported impacts include:

- **raising awareness of and interest** in construction careers among pupils and college students. Most projects' learning materials have been used to engage young people in education and to demonstrate what construction roles look like in practice. This suggests that the Immersive Learning commission may lead to an increase in the number of people entering the industry.

Indirect impacts include:

- **greater community awareness** of construction work and what it entails among local communities adjacent to tunnelling sites.
- **other impacts** and outcomes for indirect beneficiaries are similar to outcomes for the direct beneficiaries, including improved health and safety knowledge and an increased understanding of construction sites.

Value for Money

To conduct a quantitative VfM assessment a minimum of the following data should be captured from each project in addition to the funding schedules and monitoring information:

- number of employees trained.
- job retention / employment rates.
- reduction in health & safety costs / claims.
- reallocation of time dedicated to on-site production of construction services away from training. (cost saving, revenue generation)
 - more efficient use of on-site production of construction services.
- improved future training and subsequent construction industry attractiveness as a place of work.
- wider benefits could be experienced such as improvements in infrastructure development.

7.2.4 Counterfactual impact of the commission

While project leads suggested that the training content and outputs would not have been developed and delivered without CITB funding, there is insufficient evidence to conclude on what might have happened if the CITB funding had not been available and what additionality the funding provided.

7.3 Lessons Learned

Key lessons learned to date that can be taken forward include:

- **project leads and partners are positive about the future scalability of the immersive learning projects** - however, they highlighted a number of factors that should be considered to enable scaling up the projects, including:
 - the need to support trainers and colleges on how to use hardware and headsets and providing troubleshooting guidance
 - developing more content for mobile phone apps, as opposed to virtual reality content for headsets which are expensive and limit the number of employers and training providers who can access the content

- **information about outcomes achieved for trainees is difficult to capture through project lead and partner interviews** - it is important that training is followed by a short, consistent survey of trainees with a follow-up survey c 3 – 6 months later to find out if and how they applied what they had learnt. The survey should capture the trainees' experience of using the training as well as what they learned and how they are likely to use what they learned in future.
- **it is important to engage the right partners at the right point in time** - to ensure that construction companies have live projects on which to roll out content. In addition, engaging partners requires the project leads to invest time and resources, therefore it may be more productive to engage partners sequentially, depending on resources available.

7.4 Recommended Next Steps

In order for immersive learning to become central to training and development delivery, it is essential there is robust evidence that it works. The impact of COVID-19 on the commission and the lack of data collected by some of the projects has made it difficult to produce this evidence.

The projects still ongoing are particularly important in ensuring that evidence is collected to demonstrate how immersive learning can reduce costs of training as well as increase uptake, skills and learning. This will be key to the future sustainability of immersive learning.

Next steps for the remainder of the commission include:

1. Collection of outcome information from project participants, including contact information for follow up consultations by RSM. **Responsibility: Project Leads** (RSM to provide guidance on data needed by to all projects still ongoing)
2. Work with projects that are still live to ensure their data collection tools collect all evidence needed against the evaluation questions. **Responsibility: RSM to meet and provide guidance on the tools, CITB to provide communications** and **Project Leads to collect the data**
3. Reiterate to projects the need to collect and share monitoring data and participant feedback with RSM. **Responsibility: CITB**
4. Develop case studies with projects still ongoing that will demonstrate the costs and benefits of immersive learning. **Responsibility: RSM** in conjunction with the **Project Leads**
5. Additional data on activities to be collected to inform the value for money and additionality assessment in the final report (details on minimum activity data required in section 6.2). Where applicable, follow-up surveys to be completed with those supported to capture if and how they were able to implement the training or learning provided, and if they did would they have been able to do this without the support provided **Responsibility: RSM** in conjunction with the **Project Leads**
6. Consideration to be given to how project outputs and content from the final evaluation could be promoted to CITB's wider membership. **Responsibility: CITB** (options to include an event and promotion of the case studies)
7. CITB to work with projects to consider scale up options. **Responsibility: CITB after the final evaluation report.** Note the final evaluation report will cover the costs and benefits emerging from the pilots



8. APPENDIX – PROJECT PERFORMANCE AGAINST TARGETS

Improving Behavioural Induction for Highways (Lead Partner: BAM Nuttall Ltd)

Table 8: Improving Behavioural Induction for Highways - Output Performance (January 2019 – September 2021)

Output	Target by project end (September 2021)	Actual	Variance
Induction delegates receive content in a discussion-led interactive way using tablets and AR	Successful delivery	Successfully delivered	N/A
Classroom time saved	Classroom time reduced	Classroom time successfully reduced (from 3 hours to 1.5 hours for an induction)	N/A
Reference material provided for learners to return to while on site	Successful delivery	Successfully delivered (take-away app provided)	N/A
Site Induction – AR programme	<ul style="list-style-type: none"> Increased uptake of non-active English speakers Increased ability to measure learner performance through data analytics app Reduced learning hours, increased class sizes and increased learning retention for site induction Improved access to site safety, behaviour and culture information in native language Uptake of site induction programme at the other Highways sites 	<p>What is achieved based on what is known:</p> <ul style="list-style-type: none"> Reduced learning time (as stated above) Increased ability to measure performance (automatic recording of pass rates has reduced administration and recording time by approx. 5 minutes per person) <p>What there is no evidence for:</p> <ul style="list-style-type: none"> Increased uptake of non-active English speakers Improved access to site safety, behaviour and culture information in native language Uptake of site induction programme at the other Highways sites 	N/A
Engagement – VR game	<ul style="list-style-type: none"> Increased awareness of cultural and behavioural values in modern construction sites Increased awareness of cultural and behavioural values in 	VR game delivered but targets not measured in final report	N/A

Output	Target by project end (September 2021)	Actual	Variance
	modern construction sites		
Networking of learner apps controlled by a hub app that the instructor can use to monitor learners in real time	No data provided	No data provided	N/A
Number of sites who adopt the immersive learning training	No data provided	No data provided	N/A
Engagement and retention of trainees	No data provided	No data provided	N/A
Measurement and improvement of repeat / refresher training	No data provided	No data provided	N/A
Number of school visits and number of attendees	No data provided	No data provided	N/A

Source: **targets:** CITB Immersive Learning Project Target Summaries (July 2022); **performance:** BAM Nuttall Immersive Learning Final Report (September 2021)

TunnelSkills (Lead Partner: TunnelSkills Specialist Training Forum)

The 'target to date' has been calculated based on the current project payment and reporting schedule and the planned outputs and estimated on a pro rata basis; this provides an approximate estimate however does not account for e.g., if certain activities will be more targeted at specific groups at specific points in time etc. The variance figure is based on variance against the pro rata target to date.

Table 9: TunnelSkills - Output Performance (February 2019 – June 2022)

Output	Target by project end (December 2022)	Target to date	Actual	Variance against target to date
Scenario 1: Access into shafts and tunnels under construction P1-Dev – Digital 3D asset with embedded learning content	1	N/A	1	0
Scenario 2: Pit Bottom P2-Dev – Digital 3D asset with embedded learning content	1	N/A	1	0
Scenario 3: Sprayed Concrete Lining P3-Dev – Digital 3D asset with embedded learning content	1	N/A	1	0
Scenario 4: Tunnel Boring Machine P4-Dev – Digital 3D asset with embedded learning content	1	N/A	1	0
Scenario 5: Pipe jacking P5-Dev – Digital 3D asset with embedded learning content	1	N/A	1	0
Scenario 6: Hand Mining P6-Dev – Digital 3D asset with embedded learning content	1	N/A	1	0
Scenario 7: Shaft Construction P7-Dev – Digital 3D asset with embedded learning content	1	N/A	1	0
Scenario 8: Emergencies / Planning / Response P8-Dev – Digital 3D asset with embedded learning content	1	N/A	1	0
Test and pilot 8 learning experiences with 26 Apprentices	26	21	26	5
Test and pilot 8 learning experiences with 300-400 existing tunnelling employees and learners (100 to be those logged as accessing the web-based resources by Google Analytics)	300 - 400	245 - 327	656	329
Engagement – Deliver 50 experiences at careers & employer engagement events	50	41	50	9
Final project report	1	N/A	0	-1
Case Study	1	N/A	0	-1

Source: **targets:** TunnelSkills Payment and Reporting Schedule (July 2022); **performance:** TunnelSkills Payment and Reporting Schedule (June 2022)

Immersive Learning for Construction - Plymouth (Lead Partner: City College Plymouth)

Table 10: Immersive Learning for Construction - Plymouth - Output Performance (February 2019 – March 2022)

Output	Target by project end (March 2022)	Actual	Variance
Detailed interactive house digital asset for learning interventions	Successful delivery	Delivered successfully	N/A
VR health and safety modules aligned to occupations, mapped to L1OCN	Successful delivery	Delivered successfully	N/A
L1 and 2 learners / apprentices / workers receive health and safety training modules	180	No data provided	N/A
VR bite-size competency modules for technical / supervisory / management competencies	No target number	No data provided	N/A
Supervisors / managers undertake blended behavioural learning using VR twinned with real environment	26	No data provided	NA
34 Career and employer engagement events delivered	14 events in year 1 and 20 events in year 2	No data provided	N/A
Modules piloted with delegates, tutors and construction employer trainers	32 delegates, 28 tutors and 4 construction employer trainers	No data provided	N/A
Pilot training for longevity of the programme with employer related trainers	15 employer related trainers	No data provided	N/A
Number of participants (project start – March 2022)	No target number	1444 participants	N/A
VR experience rating (out of 5)	No target number	Average score of 4.6 / 5	N/A

Source: **targets:** CITB Immersive Learning Project Target Summaries (July 2022) and CCP Immersive Learning Final Report (March 2022) **performance:** CCP Immersive Learning Final Report (March 2022)

Transforming Construction Trade Apprenticeships (Lead Partner: Bridgwater and Taunton College)

Table 11: Transforming Construction Trade Apprenticeships - Output Performance (N/A)

Output	Target by project end (January 2022)	Actual	Variance
Talkout VR to work with BTC specialist trainers to video required pile cap build sequence and safety messages	No data provided	No data provided	No data provided
Talkout VR to incorporate Rebar shape codes, videos and 3D BIM build model into augmented reality platform	No data provided	No data provided	No data provided
Talkout VR to develop final augmented reality package for Pile Cap build and produce app file for download onto CSIC tablets.	No data provided	No data provided	No data provided
Talkout VR to notify BTW of app availability	No data provided	No data provided	No data provided
BTC to download and install AR app	No data provided	No data provided	No data provided
BTC to test app and ensure it is working prior to apprentices	No data provided	No data provided	No data provided
BTC to run a pilot with group of new apprentices to evaluate how this technology supports and/or enhances the learning experience	No data provided	No data provided	No data provided
BTC to produce initial evaluation report with recommendations for revised spec	No data provided	No data provided	No data provided

Source: **targets:** CITB Immersive Learning Project Target Summaries (July 2022); **performance:** N/A

Mixed Reality Training Vehicle for Specialist Learning (Lead Partner: Hire Association Europe)

The 'target to date' has been calculated based on the current project payment and reporting schedule and the planned outputs and estimated on a pro rata basis; this provides an approximate estimate however does not account for e.g., if certain activities will be more targeted at specific groups at specific points in time etc. The variance figure is based on variance against the pro rata target to date.

Table 12: Mixed Reality Training Vehicle for Specialist Learning - Output Performance (May 2019 – November 2021)

Output	Target by project end (March 2023)	Target to date	Actual	Variance against target to date
P1 Platform (module)	1	N/A	1	0
P2 Vehicle Marshalling (module)	1	N/A	1	0
P3 Intro to Hire (module)	1	N/A	1	0
P4 Mental Health (module)	1	N/A	1	0
P5 Environment (module)	1	N/A	1	0
P6 Dust, Asbestos (module)	1	N/A	1	0
Others (module)	N/A	N/A	8	N/A
Pilot with 2192 industry employees and learners	No data provided	No data provided	No data provided	No data provided
Beneficiaries employed by CITB registered organisations	1150	863	15	-848
Beneficiaries studying for construction specific vocational quals	850	638	14	-624
Beneficiaries studying for specialist skills programme or specialist upskilling programmes	152	114	14	-100
Trailblazer learners	40	30	0	-30

Source: **targets:** HAE Payment and Reporting Schedule (June 2022- output data recorded up to November 2021) ; **performance:** HAE Payment and Reporting Schedule (June 2022- output data recorded up to November 2021)

Construction Virtual Environment Resource Training (CONVERT) (Lead Partner: Construction Wales Innovation Centre (CWIC))

The 'target to date' has been calculated based on the current project payment and reporting schedule and the planned outputs and estimated on a pro rata basis; this provides an approximate estimate however does not account for e.g., if certain activities will be more targeted at specific groups at specific points in time etc. The variance figure is based on variance against the pro rata target to date.

Table 13: Construction Virtual Environment Resource Training (CONVERT) - Output Performance (May 2019 – April 2022)

Output	Target by project end (October 2022)	Target to date	Actual	Variance against target to date
Number of training programmes / modules developed	23	20	23	3
Number of training event attendees	2440	2083	735	-1348
Number of training events held	414	353	102	-251
Number of engagement event attendees	813	694	735	-41
Number of engagement events held	96	82	42	-40
Number of trainees that start the training	No target	No target	660	N/A
Number of trainees that complete the training	2440	2083	660	-1423
Number of trainers trained	120	102	54	-48
Number of employers engaged	50	43	39	-4
Number of immersive learning units produced across each Regional Delivery Hub	Multiple / TBC	N/A	140	N/A

Source: **targets:** CWIC Payment and Reporting Schedule (April 2022); **performance:** CWIC Payment and Reporting Schedule (April 2022)

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