Immersive Environments for Training, Education and Learning

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Midwifery and Nursing Skills Training

We are now on our third project with Bournemouth University, each looking at a different aspect of the training that their student midwives and nurses need.

The first exercises (designed for PC/Mac or with Google Cardboard) took the student through a Urinalysis appointment with an expectant mother. The second looked at the care of a diabetic in-patient, and the latest one is looking at safeguarding issues.

Staff and student responses include:

"I absolutely love this! A brilliant way to learn"

"So amazing to see my project becoming a reality – I hope the students love this way of bridging the gap between classroom theory and clinical practice"

"That was brilliant loved it! can't wait to do more. Very informative"

"I had such a cool day at work recently – I got to play with the first of my VR healthcare education environments using Oculus Rift"

Introduction

The aim of this white paper is to outline why organisations should be considering immersive environments their learning, training and education needs, and why they are such valuable places for students to learn in. By immersive environments we include both virtual reality (VR) and the use of 3D environments on ordinary computer screens (in the style of most computer games).

Throughout we are conscious that both public and private sector organisations are facing significant pressures to cuts costs and do more for less. As such we realise that any training or education organisation is only likely to invest in a new system if it enables them to deliver either:

- the same quality of learning/training for less cost, or
- a higher quality of learning/training for the same/affordable cost

In this document we will use the sidebars to present case studies drawn from the work of Daden clients and other thought-leaders within the immersive environment space, and to examine particular issues or topics in more detail.

What is an Immersive Learning Environment?

Initially it's probably best to be clear about what we are NOT talking about. For a start we certainly aren't referring to so-called Virtual Learning Environments (VLEs, which in the USA are normally called Learning Management Systems – LMS), which are simply systems for managing learning.

By Immersive Learning Environments we include elements of:

- 3D simulations when experienced in the first-person – you are a part of the simulation
- Virtual Worlds, where the emphasis is on agency and persistency
- Virtual Reality systems with head-mount displays, CAVEs or haptic interfaces – all could form part of an immersive learning system, but are not essential for one.
- Games - and the technology behind games is what drives most immersive learning environments
- Serious Games – which perhaps sit at the opposite end of the spectrum to simulations

To us an immersive learning environments is one where the user has **a real sense of "being there"** - regardless of the technology being used or the subject being taught.

Immersive Environment vs. Virtual World

Virtual Worlds are at once a subset and superset of immersive environments.

A virtual world is typically far more open-ended than an education based immersive environment. The user has far more scope of action, and fewer explicit goals. The environment itself is by definition multi-user, and the users can effect changes ot the world which persist over time.

Whilst these features have made virtual worlds such as Second Life ideal places for educators to explore the learning potential of immersive environments, they have often been the same factors that have limited the growth in the use of such environments in the wider education or training community.

For "ordinary" training and learning we need environments which are reliable, constrained and managed – they need to get the job done with the minimum of fuss and risk.

Virtual worlds are a super-set since we can constrain a part or instance of a virtual world to create an immersive learning environment – but often too much of the parent environment shines through to make it an ideal space for such uses. On the other hand virtual worlds are a subset of immersive learning since we can create an immersive learning environment that has all of the key features of a virtual world that we need for our educational uses – and no more.

This means we could, in theory (and in some cases have in practice) create immersive environments which are purely sound based, or even text based (think text-based adventure books). In most cases though we are talking about generating 3D environments on a 2D computer screen, and giving the user some degree of freedom to interact with that environment. If all the user can do is look at a 3D environment and choose from menu options it's probably not going to be very immersive. If they can wander through that environment, have a sense of purpose (and possibly urgency), do things AND make mistakes then we are on our way to creating an immersive environment.

It is also worth remembering that when we talk about an immersive environment we are not ONLY talking about structures and objects, we are also talking about people. Within the immersive environment we can create virtual people who can fulfil a wide variety of roles from just providing background "colour" to make a place seem busy (which in itself can often make a task harder and more realistic) to being key people with whom the user has to interact.

Why Immersive Learning?

When looking at why we should use immersive learning we need to assess its advantages and benefits over the two main existing types of learning – physical learning and eLearning.

- Compared to Physical Learning

By physical learning we are primarily concerned with learning where you have to physically (rather than just mentally) do something. These tasks are often closely linked with more vocational professions and occupations.

The learning tasks are likely to have a strong spatial element (e.g. moving around a location, handling an object), and often a strong social element (working with other people or customers). These are all things that are hard to teach in classroom setting, and if you do then often the sense of realism that you are trying to create is completely offset by the artificiality of the experience. (e.g. in role play, using masking tape to delineate spaces etc.). The alternative is to head out to a real location, but that immediately adds significantly to time and cost, and trying to "reset" an exercise after you've started can often be so problematic and time-consuming that its simpler to let the exercise run. Only a few organisations can afford to build physical mock-ups of their real-world environments (e.g. hospital simulation centres), but these can be extremely expensive. They also pull people away from their working environment which is again costly in time, money and carbon. And of course in many cases it is highly impractical, costly or even dangerous to try and create a physical world simulation of the training that is required,

whether it's how to manage a major road closure or how to deal with a nuclear incident.

In comparison 3D immersive environments are ideally suited to taking the training that doesn't work well in a classroom and delivering it as a virtual experience wherever the user happens to be – either learning solo, or in centralised or remote group learning. The application can faithfully reproduce the 3D working environment, it can populate it with virtual characters to represent customers, patients or just "other people", and as a multi-user space, team members can work and learn together.

When considering the time, cost and carbon savings that any form of eLearning can bring, make sure you include the whole cost. For instance, any off-site or centralised training will involve travel time (often the day before or in the students' own time), it may involve overnight accommodation and subsistence expenses, and the environmental impact of all the travel.

Encoding Specificity

Encoding Specificity is a key concept that lies at the heart of the use of simulation in learning. What learning psychologists and cognitive scientists working on memory have found is that "transfer [of learning] is maximum when the conditions at retrieval match those present at encoding." [CLARK2003]

In English that means that *we will be better able to remember what we learn, if the conditions during learning match those during recall*. So, if we learn about an activity whilst fully immersed in a simulation of the "real" environment that matches the real experience our learning and recall will be better than if we learn by reading books and Powerpoint, or even using a simple eLearning app, in a sterile classroom and then have to perform in a noisy factory or a busy street.

- Compared to Traditional eLearning

Of course, many have tried to overcome the challenges of training these physical tasks by creating conventional eLearning packages. Unfortunately, these tend to be dominated by simple, read-watch-click type solutions, which rarely engage the user, don't offer any sense of spatial or situational awareness, and are almost exclusively solo learning environments.

Even in non-physical training eLearning can be underwhelming and fail to motivate students or give them a full and rich understanding of what is happening. These areas often include the more academic and school type learning (e.g. History, Geography, Economics) as well as more scientific education. In these areas there are many topics that lend themselves to an immersive 3D experience, whether it's exploring a virtual Rome, or seeing the inside of a virus.

Another key factor is that research on memory and understanding has shown that there is a level of ***"encoding specificity"*** that occurs when we learn – i.e. we remember better when learn a task or fact in the same environment as we'll have to actually use it. In both eLearning and classroom learning this encoding specificity is lost – but can be regained by immersive learning.

- Summary

So, whilst there are many topics which are well served by eLearning, there are also many where it struggles to provide a satisfactory (and effective) educational experience. And classroom (and e-) learning are often very poor substitutes for the expensive (and often impractical) alternative of getting out into the real environment.

The potential advantages and benefits of immersive learning against these two traditional approaches is summarised in the table below. Alternative views on the same topic are also provided in a couple of the sidebars.

	Physical Learning	eLearning
Advantages	Spatial awareness Team working Social engagement Reality Encoding specificity	Simple to create and deliver Access anywhere
Challenges	Cost, time and carbon Practicality of doing in the field Near complete loss of realism when done in the classroom	Low engagement, superficial understanding Poorly suited to spatial and social subjects No encoding specificity
Immersive Learning Benefits	Retain most of the advantages of physical learning within a classroom or remote/single user session Avoids expenses of cost/time/carbon	Higher engagement Different pedagogic models (eg exploration) Social and team learning Well suited to spatial and social subjects Encoding specificity

In all of this it is also worth remembering that immersive learning is usually used as part of a blended learning experience. Physical learning, conventional eLearning and immersive learning all have their part to play, and each should be used to play to its strengths according to the type of training being delivered, the training context and the nature of the learners.

Roles and Uses

Trying to list all the ways that immersive learning could be used is pretty futile, but here are some of the ways in which we have seen it being used to give you some idea of the potential:

Area	Uses
Businesses and Organisations	Sector Specific Skills Onboarder & Site Familiarisation Health & Safety Customer Care & Relationships Inter-cultural & Language Training Management, Leadership and Team Skills Business Continuity & Emergencies

Immersive Environments vs Video

A number of projects that we get involved with would traditionally have been done using video – since video has the richness and dynamism lacking in most traditional eLearning.

With immersive environments we can potentially get the best of both worlds – the interactivity and control of eLearning, and the engaging graphics and narrative of video. To the surprise of many the costs of immersive learning projects are often comparable to video – yet with more flexibility and shelf-life.

There is also a good case for using immersive environments to deliver very video style content (e.g. passive viewing of a dynamic scene), for instance watching an interview or a demonstration or fly-through. The problem with video is that once its cut and published it's fixed – and changing it can be expensive or near impossible (e.g. the actor is no longer available). With an immersive environment, we can change almost any part of the text or fly-though instantly, so we can always keep the learning bang up to date.

Area	Uses
Universities	Vocational led courses such as nursing, medicine, paramedics, social work, psychology Land based courses such as civil engineering, geology, geography, history Science based courses such as biology, molecular chemistry
Colleges	Vocational led courses such as health & social care, customer service and construction NVQs etc
Schools	Exploring historic sites and speaking to historic personalities Virtual geography, geology and environmental field trips, from volcanoes to favela STEM education – from visualising complex mathematical shapes to flying inside the body and doing virtual experiments Social skills, including anti-bullying and dealing with gangs, drugs and other aspects of street culture

Does it work?

Of course, words are great, but does this technology actually deliver in the real world. We have been tracking the performance of a variety of immersive learning projects over the years – both our own and those from other suppliers within the industry, and the following table summarises some of the results being obtained.

Project	Results
Immersive virtual worlds: Multi-sensory virtual environments for health and safety training. Institution of Occupational Safety and Health and University of Nottingham, 2019 [LAWSON2019]	The results of this study suggest potential benefits of virtual reality/multi-sensory simulation to OSH training, for example through increased engagement and due to the fact that there was evidence of a more direct experience with the environment, which is known to be a learning advantage. While participants trained through PowerPoint presentations had a greater increase in knowledge test scores (from before undertaking training to immediately after), there was a significantly larger decrease in knowledge scores when participants were re-tested one week later, demonstrating that retention was better with the VR. The mean score on the final test was therefore actually higher for the VR condition, despite the short-term improved performance for PowerPoint.
Why Immersive? Using an Immersive Virtual Environment in	"The results clearly demonstrate the pedagogical role played by Interactive Virtual Environments (IVEs) in enhancing design activities and supporting peer participation.

Architectural Education. Faculty of Architecture and Town Planning, Technion [SOPHER2017]	The research results underscore this environment's substantial capacity for encouraging the emergence of synthesis learning activities. The findings show that the IVE supports different use patterns according to personal skills and learning profiles."
Simulation-Based Learning: The Rise of the PlayStation Professionals. eLearning Guild [GRONSTEDT2018]	Study after study has already demonstrated the efficacy of virtual reality learning: • Training professional football quarterbacks with VR improves their decision-making by 30 percent and helps them make decisions about one second faster • Fear of public speaking was reduced by almost 20 percent with VR • Almost 90 percent of participants reduced their fear of heights with VR • Lowe's found that customers have 36 percent better recall of how to complete a tiling project using VR compared to video • Walmart, the world's largest employer, has expanded VR training to all of its 200 employee training centers in 2017, after testing it in 31 centers, and will train 140,000 employees annually in VR • Equipment rental company United Rentals shortened a weeklong training program by half with VR
University of Colorado Meta-Analysis **[SITZMANN2011]**	A meta-analysis by the University of Colorado in 2011 of 65 serious game and simulation projects identified that "post-training self-efficacy was 20% higher, declarative knowledge was 11% higher, procedural knowledge was 14% higher, and retention was 9% higher for trainees taught with simulation games, relative to a comparison group."
Triage Trainer (Blitz Studio)	28% vs 7% for tagging accuracy for simulation trained students [DEFREITAS2009]
Imperial College Operating Theatre Familiarisation and Training Ward	Higher confidence from immersive environment group as against those receiving a lecture or even those visiting a real operating theatre 82% of nurses who used the Training Ward simulation would recommend its use for nursing students. [IMPERIAL2009]
Loyalist College Border Crossing Trainer -	Success scores raised from 56% to 98% in one year [LINDEN2009]
St George's Paramedics	80% students said will help them to manage patients, 100% saw it as a relevant resource for field/clinical work preparation [PREVIEW]

Virtual Avebury and Virtual Heritage

Heritage is a natural area in which to apply immersive learning, placing people (be they members of the pubic, students, researchers or archaeologists) into an environment "as-it-was" in order to better understand context and what the place actually felt like to live in.

Funded by AHRC in 2018 we worked with the National Trust, audio-specialists Satsymph and Bournemouth University to create a simulation of what the Avebury Ring site may have looked like when it was built several millennia ago.

The terrain was derived from Environment Agency LIDAR data, then "back-dated" with the advice from archaeologists. The Principal Investigator then used Trainingscapes to lay out the 200+ stones, and we incorporate a unique soundscape using Trainingscapes sound objects.

Two VR systems were installed at the NT's visitors centre, so the public could experience the site "as-was" whilst seeing it "as-is". Being a multi-user system meant that kids could chase each other between the stones – and it became a social experience, not just a learning one.

The Learnovate Centre published a useful summary report on "The Use of Serious Games in the Corporate Sector" in Dec 2012 [DONOVAN2012]. The report concluded that:

"Corporate training is facing major challenges. Employees are no longer engaging with traditional forms of training including eLearning, finding the whole experience 'unexciting' and 'boring'. Consequently, there is a need to make training more engaging, relevant and 'sticky' because a well-trained workforce impacts key business drivers.... New models of training, more relevant to the workforce of today and tomorrow need to be explored. Games-based learning is one such model. There is empirical evidence to support its learning effectiveness across all three domains of learning … Serious games have a valuable role to play … and should be considered as an integral part of corporate learning strategies"

Some of the quotes from learners are also illuminating as to the more qualitative benefits that immersive learning delivers:

- "Communicating with others helped assess the situation and gave me a better understanding"
- "It's much better to be able to actually perform treatments rather than just talk about it."
- "The open nature lends itself very strongly to creating a rich and valuable decision-making exercise."

Styles and Pedagogies

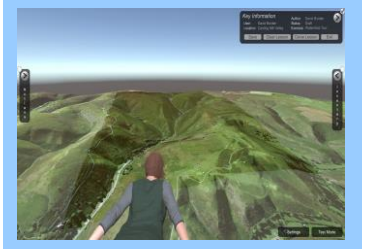
One of the features that we particularly like about immersive worlds is that they are pedagogically neutral. This means that once you've built the 3D environment you can create a wide variety of different learning experiences, approaching the learning in different ways according to the nature of the user, training and stage of learning. Some of the most common approaches are:

Approach	Description
Exploratory	The user is placed in the environment, and then moves through it at their own pace (and in their own direction), activating items (and learning nuggets) of interest. This can be ideal for a general introduction and to get students motivated and interested in a topic, but is often followed by a more structured exercise. It is also useful though when the student enters revision mode. Staffordshire University has quite a nice 4 step model to support this [STAFFS2013].

Virtual Fieldwork

The first project we did with Trainingscapes was to create a virtual field-trip for Geography students. We created a 3D model of Cardingmill Valley, and all the props that students on a typical GCSE or A Level field-trip might use when doing a river measurement exercise in the valley. The exercise then took them through all the tasks they would be expected to do for real, so they could rehearse before arrival, and revisit before exams. Tasks included the use of a virtual tape measure, virtual inclinometer, and even measuring river depth and flow.

Being a virtual environment we could also offer "not-possible-in-real-life" experiences, such as a flying hoop tour of the valley watershed so that students could appreciate the context of the valley – something they rarely get to do on a physical fieldtrip.



Approach	Description
Structured	The student is led step by step through a learning exercise, having minimal scope of action between (or even in) each step. This ensures that all the learning is covered – essential for regulated courses – but can demotivate if not well presented or the student feels too much on a treadmill. This is the closest to the typical eLearning course.
Task	The student is given a particular task to do – but a relatively high degree of latitude as to how they achieve it. This can be challenging to tutors to create as it forces them to think in a non-linear way. It becomes far more like eDrama – with the student marshalling "props" and talking to "actors" to achieve the task. This is where immersive environments can really shine, as the give the student a real sense of participation, control and achievement, and don't limit the options at each stage to a set of tick lists and a simple branching structure. Task learning is usually proceeded by some structured and/or exploratory learning, and may often still include some scaffolding to help with the learning and keep the student on track (for instance we find a "traffic lights" system useful to indicate whether actions are a good or bad idea).
Assessment	Once the student is showing mastery of a task we can enter an assessment phase. Again we can use a "task" type approach, but this time with no scaffolding so as to see how well a student might be able to complete the task in the real world. And unlike much physical assessment we know that we have a completely repeatable exercise, and a completely consistent scoring system.

Benefits of Virtual Learning

Writing in the British Journal of Educational Technology (Jan 2010), Dalgarno and Lee [Dalgarno2010] identify 7 learning affordances of 3D virtual environments:

- Facilitating learning tasks which lead to the development of enhanced spatial knowledge representation
- Facilitating experiential learning tasks which would be impractical or impossible to undertake in the real world (including simulations)
- Creating simulation of abstract environments which embody concepts and principles which are not normally accessible to the senses (via Winn & Jackson 1999, also referred to as microworlds)
- Facilitating learning tasks that lead to increased intrinsic motivation and engagement (due to high levels of personalisation and immersion and being "in the flow")
- Allow learners to approach concepts as "first-person non-symbolic" experiences, in contrast to most instances in which information is codified and represented "third-person symbolic" (via Winn 1993 and Dickey 2005)
- Facilitating learning tasks that lead to improved transfer of knowledge and skills to real situations through contextualisation of learning (i.e. learning in an appropriate realistic simulation)
- Facilitating tasks that lead to richer and/or more effective collaborative learning (due to the 3D social interaction and negotiation)

Key Design Decisions

One thing that we have found in developing immersive experiences over the years is that there are often choices to be made that have a significant impact on the learning experience. In many cases these are not either-ors, but rather whereabouts on a spectrum that the choice sits.

These are some of the decisions (or spectrums) that we encounter:

- Simulation vs Serious Game

In recent years this has become the big one – to what extent do you want the immersive experience to be a "simulation" of reality (so high on accuracy), and to what extent do you want it to be game-like (and so highly motivating)? The situation gets even further confused when people start talking about "gamification".

Having been involved in games design since before the days of personal computers we know that this really all comes down to game mechanics. To us something becomes a "game" as soon as you start to introduce (or exclude) rules or features that do not exist in the real world. Those things you introduce are called game mechanics – and might range from a simple countdown timer or scoring system to highly artificial features such as power-ups and upgrades.

Our traditional work has been towards the simulation end of the spectrum, but more and more clients are after "serious game" type solutions. This means introducing the right game mechanics to achieve the desired goals (both learning and motivational), but without losing sight of the overall purpose and context.

- Linear vs Freeform

When we first engage with tutors and learning designers who have been used to working on eLearning projects we find that they tend to come with a very linear mindset. The learning is a sequence of actions and tasks, and each screen only provides a few options as you don't want to crowd the screen or confuse the learner.

Coming from a virtual worlds background we are far more used to open learning spaces with lots of possibilities – trying to get tutors and designers to "unlearn" can be hard.

One of the best approaches we have found is to get them to think of a learning exercise in terms of drama, or even e-drama.

- What is the setting of the scene (the set/3D environment)
- Who are the actors (the learner, other learners and the non-player characters)
- What are the props, and what can the learners/actors do with them

In fact, it's not even scripted drama we're often after, it's improvised drama. It's telling the student: this is the scene, here are the props, the actors are going to do something and you need to respond.

Thinking things through in this way can help to bring out the explicit (and implicit) props, actors and actions/options that a scene will need, and then having created those we can build whatever script, structure or scaffolding we need on top.

- Realism vs "Not Possible In Real Life"

Immersive environments are incredibly versatile, they can just as readily create an environment that is highly realistic as they can one that is totally "not possible in real life (NPIRL)". At the more extreme end NPIRL may mean doing virtual geology trips to the moon, but it can also just as well mean repeatedly going through the medical activities associated with someone dying. The more extreme situations can help engage and motivate students, but they need to be balanced by the sort of tasks that the students are most likely to encounter in real life. One of the big advantages of immersive environments (and why they are so widely used by the military) is that students can undertake a lot of iterations of the same basic scenario – but with variations ranging from the totally expected to the wholly unexpected.

- Avatar vs No Avatar

On the face of it this is an either-or decision - is the user represented by an avatar or not? In our experience whilst the avatar can help a lot with identification and spatial awareness many users (and especially business managers) associate avatars with games (and so have trouble taking it seriously), or get so hung up on the appearance of their avatar that they miss the learning.

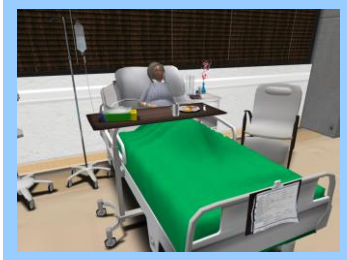
However, with modern immersive environments this isn't a decision you have to make. We can design immersive environments so that the user can switch easily between avatar and avatarless modes. Also, where sections of learning don't really need an avatar we can hide the avatar for that section – completely tuning the experience to the learning and the user.

Other Projects

Some other projects we've done include:

A 5-hour Disaster Management simulation for the City of New York – a year before Superstorm Sandy struck!

A Customer Service NVQ trainer for the University for Industry, mixing interaction with automated bots and avatar based role-play.



End of life care training for nurses at University Hospital Birmingham.

Virtual laboratory training at the Universities of Leicester and Hong Kong.

Digital Simulation Criteria

A July 2013 report by the London Knowledge Lab [LKL2013] on "The Potential to Coordinate Digital Simulations for UK-wide Vocational Education and Training" had this useful list of criteria for building a digital simulation, which would apply to almost any organisation:

1. The skill is basic or fundamental to employment opportunities but is also expensive, dangerous, or difficult to practise in the authentic context.
2. The authentic practice is inaccessible to some groups of vocational learners e.g. young learners, those with disabilities, and simulations can open up some aspects of the curriculum for them.
3. It widens opportunities for cross-subject use, providing additional experiences for other vocational learners.
4. Real provision is environmentally costly relative to the simulation, the cost of which is sustainable in the long term.
5. The simulation enables development of a skill over time, with supported independent practice leading to improving technique or understanding.
6. It achieves the pedagogic value of learners being able to practise repeatedly, at their own pace, independently of the teacher, but with support through feedback from the simulation, to gain a thorough grounding in the skill and concepts.
7. The simulation is sufficiently interesting and important to be seen as a marketable feature for enrolling at the college.
8. The simulation enables formative assessment of the learner's progress, offering the learner the ability to reflect on their achievements and plan their next steps.

They also identified 5 types of simulation: serious games, systems models, modelling tools, role-play simulations and scenario simulations.

- 2D vs 3D

We have similar flexibility when it comes to presenting information in 2D or 3D (or even 2.5D – typically a fixed camera oblique view). Just because we are using a technology capable of doing 3D doesn't mean we *have* to use 3D. If a piece of learning is best dealt with in 2D or 2.5D then we can switch into that mode, and then back to 3D when appropriate. We know that students often find 2D and 2.5D easier (and it is easier for us to manage and control), so we often design the learning to start in 2D and then slip into 3D once the context has been set. We also regularly pop-up a 2D panel over the 3D world when we just need to show text, images or a video, and also uses posters and computer screens in the 3D world to show 2D information as we would do in the physical world.

The bottom line is that 2D and 3D work together in the physical world – so we should likewise use them together in the virtual immersive world.

- Single vs Multi User

A major design decision is whether an environment is designed to be used by a single user (so they only see themselves) or by multiple users (so everyone sees and can interact with everyone else). Obviously multi-user is essential if you are looking at team and collaborative learning, or you want staff (or actors) to role-play characters in the simulation "live". But multi-user suggests an element of scheduling, and also requires the users to have a network connection, so doesn't give the individual learner the maximum flexibility (e.g. learning on the underground), or let them practice in private.

Again, we can cope with most situations with a single application, letting the user choose at start-up whether they want to enter the environment in Single User or Multi-User mode. We can also provide hybrid environments such as:

- Where the users can all see and communicate with each other, but any interactions they make with the environment are purely visible to them alone
- Having different "instances" of the learning environment, so that multiple classes can use the environment at the same time – but can only see and interact with the people from their own class.

Making an environment multi-user does add to the cost, and is best done at the very start; having different instances adds even more to the cost. So, this is a key early design decision based on your proposed usage model and budget!

Site Familiarisation and Fire Safety

Virtual environments are great places to train things which are too dangerous or problematical in real-life. One of our favourite demos is a fire-safety trainer, showing the effect of different fire extinguishers on different types of fire. In ten minutes we can put someone through half-a-dozen fire incidents, bringing home in a very visceral way which extinguisher to use for which fire.

This image beautifully shows a user "flinching" as they use the wrong extinguisher and the virtual fire flares out of control.

More prosaically virtual environments can be used to complete virtual site familiarisations, using a mix of 3D models and real on-site photos – a complete virtual on-boarding experience.

- Synchronous vs Asynchronous

The final choice is only relevant in multi-user mode – should the environment be designed for asynchronous use – i.e. everyone uses it at their own time and pace, or for synchronous use – more like a physical world team learning session where the team (and the tutor/assessor) are all present at the same time.

In asynchronous mode we are really talking about lots of individual single-user experiences, people using the environment as and when. With synchronous mode we are talking about timetabling and co-ordination, but the benefit is that we get to practice those team tasks that it may just not be feasible to practice and rehearse in the physical world due to limitations of time or distance.

Immersive Learning Design

When it comes to designing an immersive learning exercise there are a lot of traditional design methodologies that we can adopt, as well as some more specific to immersive environments.

We assume that you have already conducted a Training Needs Assessment to work out what needs to be trained, and that immersive learning is a sensible option for the learning. From this base the design process can be informed by the following models which:

- Think about the overall design of the learning process (immersive or not) – Bybee's 5E and Merril's First Principles
- Look at the specifics of immersive learning (De Freitas 4 Dimensional Model)
- Think about assessment strategies (Kirkpatrick)
- Think about all of the key stakeholders (Balanced Scorecard)

- 5E Model

The 5E model [BYBEE2006] (used by NASA and others) is a very general model of learning, and applies to physical and eLearning, as well as immersive learning:

Engagement	Object, event or question used to engage students. Connections facilitated between what students know and can do.
Exploration	Objects and phenomena are explored. Hands-on activities, with guidance.

Medical and Social Research

Virtual environments are great places to conduct experiments which might be too time-consuming or impractical to carry out in real-life.

For Birmingham Community Healthcare Trust we created a virtual urban environment where people with acquired brain injury (ABI) could be tested on their ability to navigate within a street network in order that the steps needed to help them reacquire vital everyday navigation skills could be rebuilt.

The street network was the fixed environment, but researchers could then use the drag-and-drop editor to place both proximal landmarks (e.g. a pillar-box) and distal landmarks (e.g. a crane or church spire) to test navigational capabilities.

Client feedback included:

"Daden were very customer centred, checking with us at each stage in the development that it was exactly what we wanted. None of our very 'un' technically phrased questions were ever too much for them"

"The [evaluation] data was certainly more than we had expected and the software was very easy for us and the participants in the study to use"

Explanation	Students explain their understanding of concepts and processes. New concepts and skills are introduced as conceptual clarity and cohesion are sought.
Elaboration	Activities allow students to apply concepts in contexts, and build on or extend understanding and skill.
Evaluation	Students assess their knowledge, skills and abilities. Activities permit evaluation of student development and lesson effectiveness.

We can see how an immersive learning environment can be used to support all these stages, possibly game based during Engagement, an open, exploratory nature with structured elements in Exploration, collaborative and interactive in Explanation, simulation with scaffolding based in Elaboration, and pure simulation in Evaluation.

- Merrills First Principles

Merrill's five First Principles [MERRILL2002] offer another useful perspective on how people learn, and how we can design immersive learning experiences to maximise the learning opportunity for the student.

Task/Problem Centered	Students learn more when the instruction is centered on relevant *real-world tasks* or problems, including a series of tasks or problems that progress from simple to complex.
Activation	Students learn more when they are directed to recall prior knowledge, to recall a structure for organizing that knowledge, or are given a structure for organizing new knowledge. This activation can also include a foundational learning experience upon which new learning can be based.
Demonstration	Students learn more when new knowledge is demonstrated to them in the *context of real-world tasks* or problems. The knowledge that is demonstrated is both informational and skill-based.
Application	Students learn more when they perform *real-world tasks or solve real-world problems* and receive feedback on and appropriate guidance during that application.
Integration	Students learn more when they are encouraged to integrate their new knowledge into their life through reflection, discussion, debate, and/or presentation of new knowledge.

[From Wikipedia]

The repeated use of the phrase “real-world tasks” in these definitions highlight just how relevant immersive learning can be to implementing them.

Six barriers to innovation in learning and teaching in MUVEs

Steven Warburton of King's College [WARBURTON2008] wrote an interesting piece on the barriers to using virtual worlds in education. He identifies 6 main barriers:

- Technical - machine and human related [and standards related]
- Identity - the tension between playfulness and professionalism
- Culture - reading the codes and etiquette of the virtual world
- Collaboration - building trust
- Time - even simple things take time
- Economic - nothing is for free

But strategies are developing to address each of these – from improvements to the client to reduce technical issues, through reductions in time and cost from greater experience and pre-built solutions, to avoidance of culture issues from stand-alone solutions.

- 4D Model

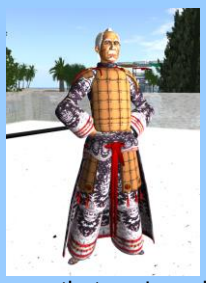
The 4D Model [DEFREITAS2010] views the learning experience in four different dimensions, as shown in the diagram below.

Learner Specifics	Representation
Learner profile Role Competencies (inc IT/Gaming)	Fidelity (Environment, Task, Interaction) Interactivity (how much, freedom, logging) Immersion (sound, emotion)
Context	**Pedagogy**
Environment (office, bus?) Access to Learning (IT) Support resources (paper, video)	Associative Cognitive Social/Situative etc

The model is useful since as well as having us think about the actual learning pedagogy, it also encourages us to consider where the user is coming from (including their IT/gaming skills), the context of the training (including access to IT), and how we represent the 3D learning environment and the actions within it. This latter consideration can also be expanded by considering Prof Bob Stone's three “dimensions” of fidelity [STONE2012], which is another valuable tool:

- **The fidelity of the environment:-** which is where you can really burn money if you want Grand Theft Auto level graphics – and there is a definite danger of making the environment so “beautiful” that it detracts from the learning
- **The fidelity of the task:-** how much the sequence of actions – and their consequences, reflects reality – and this is where our immersive experiences typically focus
- **The fidelity of the interaction:-** which covers issues like haptics and force feedback and is typically not well handled by current game engines – although this is changing

Chatbots and NPCs



One area that we've always done a lot of work on is in creating "non-player-characters" (NPCs) - the avatars that your learners see and interact with in a learning environment, but which are controlled by the learning application rather than other learners, tutors or actors.

We typically define 3 levels of NPC:

- **Background:** The people walking down a street but who do not interact with the learner, they just make a place look busy
- **Foreground:** Characters with whom the learner may have a brief interaction, but not an extended conversation
- **Feature:** Characters with whom the learner will have an extended conversation or interaction with.

Think of this in terms of appropriate levels of fidelity, and again in terms of eDrama – extras, walk-ons and real actors!

Trainingscapes has a drag-and-drop authoring tool for simple NPC dialogue design, For more sophisticated interaction we have spent a lot of time developing our own chatbot engine which can simulate natural language conversation, and even emotional response, to a learner conversation.

As well as playing the actor role such NPCs can also do duty as virtual guides, tutors and mentors.

- Kirkpatrick Assessment Model

Our next model is to do with assessment – since the whole aim of the project is usually to make a long-term real impact on the student and the organisation. Kirkpatrick's training evaluation model is simple, and probably the most widely known:

Lvl	Title	Description
1	Student reaction	What they thought and felt about the training (by survey at end of training)
2	Learning	The resulting increase in knowledge or capability (by test at end of training)
3	Behaviour	Extent of behaviour and capability improvement and implementation/application (by observation in the workplace)
4	Results	The effects on the business or environment resulting from the trainee's performance (by business metrics)

We can build both Level 1 and 2 assessment into the immersive learning application. And since the application can simulate the workplace environment we are maximising our chances of getting a good assessment at level 3, and by extension impacting the Level 4 measures.

- Balanced Scorecard

Our final model looks at the project as a whole. Everything so far has been very learner centric – and whilst they are obviously key to the learning experience there are other stakeholders in a learning project we need to be aware of. We have always liked the idea of the Balanced Scorecard as a way of tracking the performance of a business. Several people have used the traditional balanced scorecard measures (Financial-Customer-Process-Learning) to evaluate eLearning projects and initiatives. Our concept is to use the scorecard to plan and track an immersive learning project (or indeed any learning project) in terms of its key stakeholders:

Learner	Is the Learner getting what they need out of the learning, typically in terms of applicable and useful new skills/knowledge, with minimal fuss and in an acceptable and accessible form?
Trainer	Does the application/programme help the trainer meet their role and organisational objectives, and do they still feel that they have a valued place in the educational process?

Organisation	Is the organisation reaping the business benefits that it requires from the training, in terms of changes in performance, culture etc? And is the learning cost effective?
Supplier (i.e. Daden)	Do we, as a supplier, feel that the project has helped us develop – both in terms of interesting subject domain and in creating an elegant application with an appropriate amount of challenge, and has it been profitable (since otherwise we're out of business!)?

Youth Citizenship

Another project which led on social skills (and even cultural awareness) training was a youth citizenship exercise we developed for a youth project in South Lanarks Council – on the edge of Glasgow.

We created a deliberately gritty environment, with virtual alleys you felt dubious about going down.

The exercises revolved around issues such as gang culture and knife crime, and let the students explore issues and responses, and to discuss them afterwards.

One of the challenges was making the environment feel threatening – after all it was just a PC programme – but we found some nice ways for the NPCs to "physically" threaten and intimidate the learners, so that they soon learnt to deploy the appropriate responses.

Challenges and Pitfalls

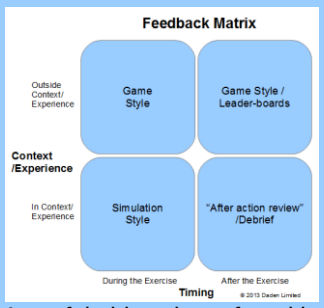
With a technology as (relatively) new as immersive environments there are bound to be challenges and pitfalls in design and implementation. The following highlights some of the key things to watch out for.

– Technical

Whilst things have improved a long way since the early days of virtual worlds such as Second Life there are still some technical considerations to bear in mind which looking at deploying an immersive learning experience:

- **Can the PCs handle the graphics?** - At Daden we know that most of our customers do not have access to the latest gaming PCs – they use ordinary business computers. So, we make sure that we design and develop applications that can cope with this lowest common denominator.
- **Can the network handle the bandwidth?** We develop our applications in Unity. This has two important implications for bandwidth. First, if you are using an application in solo/stand-alone mode the only major bandwidth use is when you first download the application – and that is typically only a few hundred MB. If the application is using dynamic content and tracking/logging then there will be some data needed as the student progresses though the exercise, but these are typically just small text files or images. Second, if the application is multi-user then there will be real-time updates sent between users, but these are only position and status information, so packet size is very small. All told, the applications should not cause a major issue on corporate and educational networks.
- **Are the ports open?** When operating in multi-user mode then the real-time updates are typically sent on their own ports through the firewall – so you may need to liaise with the IT department to have them enabled.

Feedback



A useful aid we have found in immersive learning design is this feedback matrix.

We look at the feedback provided to the learner in two dimensions:

- Is the feedback provided during or after the exercise
- Is the feedback provided in the context of the exercise (e.g. the patient turns blue) or out of context (your score goes down).

Where we provide feedback out of context we are creating a more game like experience, whereas when we provide it in context we are providing something closer to a simulation.

If we provide the feedback during the exercise then it allows the student to adjust their actions appropriately. If the post exercise feedback is provided in-context – e.g. a virtual debriefing room – then this extends the sense of simulation, whereas if we provide it as a leader-board and score it can potentially turn even a simulation experience into something more of a game – and if students start to "game" the simulation, then as in real life you may not get the results you expect.

- **Can you change the desktop?** Many corporate IT environments prevent you from installing new software on the desktop so the application may need to be centrally distributed.

– Social

As covered in the 4D model above, we need to think about where the learner is coming from, and in particular:

- What level of computer literacy do they have?
- What types of computers and devices will they be using – and where?
- Are they familiar with computer game "norms" - in terms of both behaviour and graphics?
- Are they familiar with avatars – or are they hostile to them?

As mentioned we can typically design an experience so that it can be delivered with or without avatar, and even with point-and-click rather than turn-by-turn navigation. That may make the learning slightly less effective, but it's better than frustrating or switching off the user completely.

- Learning

If we follow a good learning design methodology then we should have an effective learning process, but there are still some potential pitfalls that are unique to immersive learning environments:

- If we go for too high a level of detail the user can get sucked into the eye-candy and lose sight of the learning. Too low a level of detail and it ceases to have that "real world" sense (unless we are deliberately designing a "zero fidelity" abstract simulation).
- If the simulation does not model the critical parts of the real world task in the correct way there is a danger that the students "learn the simulation" rather than learning the real-world task.

Costs and Cost Drivers

Answering the question "how much will it cost" without a decent specification is always hard, but we believe that potential clients should at least have an idea of the ballpark for the costs, and the drivers that will push costs to either end of that range.

Most of the immersive learning projects we have done in the past have cost between £20k and £80k, with a few beyond that range (in both directions). These are costs comparable to video or eLearning production. Within this the major cost drivers are likely to be split into two groups: those affecting the visual environment,

and those affecting the learning. However, with Trainingscapes systems we are able to reduce cost of entry into 3D immersive learning to under £5k, possibly even less.

The main cost drivers and their potential impact on costs are summarised below:

- Visual Environment

Cost Driver	Impact Level
Area covered by model/landscape	Low
Complexity of buildings (interior/exterior, straight lines vs curves)	Medium
Level of detail/realism	High
Amount of interactivity (e.g. lights, lifts)	Low
Complexity of crowd/traffic	Medium
Day/night environments	Low
In-world building	Medium

- Learning

Cost Driver	Impact Level
Number/type/complexity of training steps	High
Duration	Low
Degrees of learner freedom	High
Number of avatar choices	Medium
Complexity of NPCs	High
Sophistication of self-authoring	High
VLE/LMS & other integration	Medium
Delivery devices (web, PC, iOS, Android)	Medium

3D as the User Interface

One thing that we have always maintained is that you should treat the 3D immersive environment, and particularly the technology behind it, purely as a user interface.

When actually developing learning content – be it logic, text or anything else – the more we can keep that out of the 3D technology the better. In the past we've developed web based systems such as PIVOTE and OOPAL to provide a web interface to manage and author the logic and content of an immersive learning exercise, and we are continuing the same approach with our work on the Unity3D platform.

An extension of this is when we use the 3D environment to interface to a complex, existing simulation, but one which does not already have a rich 3D interface. Examples might be a physiological model of the human body, or a complex electrical circuit or chemical process model.

For one client in the USA we have taken an existing radio network simulator and interfaced it to the immersive environment. Students sit in virtual tents and use accurate models of the radios, so they get the benefits of immersion AND the benefits of using a high grade, high precision simulation engine.

– Levels of Detail

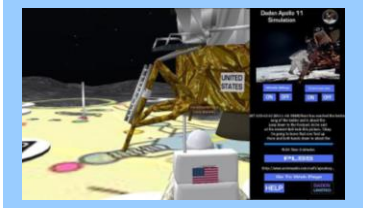
As noted above, the level of detail of a build can often be a major cost driver. Today's students may well be used to Grand Theft Auto levels of detail, but few learning and training organisations have the budgets to support that. As mentioned earlier it's all about deciding what is the right level of graphic/environmental fidelity to support the learning, and not distracting the student by going overboard.

On a learning led project we find that the 3D environment typically accounts for about 20%-30% of the budget. We define three levels of detail that we typically build at, as outlined below.

STEM (Science, Technology, Engineering and Maths)

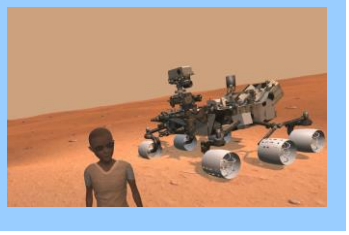
Virtual environments are an ideal way to help engage students with STEM subjects, and let them learn in ways that are just not otherwise possible – such as working on a planet or crawling inside a cell.

The image above shows a student exploring the surface of Phobos, and appreciating just how large Mars would be seen from the Moon (a good opportunity for some trigonometry lessons!)



For North Lanarks Council we recreated the Apollo 11 landing, complete with a map showing exactly where Armstrong and Aldrin walked, and where photos were taken so they can be seen in context.

All these are available on Trainingscapes, and we even have bits of Mars too!



High Detail	Standard Detail	Low Detail
Cost +50% to 100%	Base cost	Cost -50%
Fine object detail	Some object detail	Basic object shape
Texture/embossing	Shine and Shadows	Plain colours
Photorealistic		Typical CAD/iFC import

And remember that not all parts of a build need to be done to the same level.

TRAININGSCAPES

Trainingingscapes is Daden's 3D/VR immersive learning and training engine developed to let almost anyone create a 3D or VR immersive learning or training experience, and distribute it to, and manage its use by, students and trainees. It draws on our extensive experience of creating immersive learning exercises for a wide variety of clients in the UK and abroad. Trainingscapes can help you provide a variety of engaging, immersive experiences for your students, employees and other users, delivering the features and benefits described above.

An overview of the Trainingscapes system are shown below.

The key elements are:

- A cloud-based service which stores all the lessons, 3D assets and student/learner accounts and analytics
- 3D assets bought or created from almost any source/app, and imported into Trainingscapes.
- The what-you-see-is-what-you get authoring tool to create your exercises (PC or Mac download)
- The exercise player, available as PC or Mac download, iOS and Android download (for tablets and smartphones), and for Oculus VR Headsets (others as requested). The player can work in single or multi-user mode – the latter supporting text and voice chat between users
- A web-based management app to assign students to exercises and to gather learner analytics. Data can be exchanged with your VLE/LMS.

Sample Locations

The following as a minimum are available in Trainingscapes for free. Bespoke environments can also be created, and users can share their environments with other users on the system if they want.

A campus building and area

A simple office building

A small clinic/hospital

An industrial complex

Rural locations

- Asset Creation

3D assets (the location/"stage" and "props") can be bought or created from almost any source/app. There are lots of freelancers around with excellent 3D skills, and even school and college students, as well as your own eLearning or Graphics department. We also provide free and premium libraries with Trainingscapes and some generic environments such as:

- A campus building including exhibition galleries, an open events/collaboration area, and exterior meeting spaces both formal and informal
- A simple office building set-up with work areas, conference rooms, reception, kitchen
- A small clinic/hospital, including wards, operating theatre, laboratory and consultation rooms
- An industrial complex
- Rural locations, both based on real places and imagined
- A simple urban environment
- Models of parts of the Moon, Mars and deep space!

The 3D assets are then imported into Unity, grouped into "inventories" and then exported as an Asset Bundle, which is then uploaded to the Trainingscapes service. This is a pretty mechanical process and a dozen or so assets can be placed into an inventory and imported into Trainingscapes in under an hour.

Once in Trainingscapes the assets can be used for a wider variety of exercises as they are just "objects" with no inherent behaviours.

Virtual Skiddaw

We developed the Virtual Skiddaw project for the Open University course in Geology. Students who were not able to attend a real field trip were originally sent a video of a field trip – but this lacked a lot of the context and gave the student very limited freedom or scope to explore on their own.

Working with the geologists at the OU and a specialist survey firm we modelled 100 sq km of the Lake District using aerial radar and photography, and then used photogrammetry to model 6 survey sites, and individual rocks at each.

After avatar and kit selection the student receives a text and audio briefing and is then guided to each of the sites. At each site they have a number of tasks - from making sketches and looking at the rocks through a virtual microscope to taking an aerial view to look at Ordnance Survey and geological maps.

The net result is that the student has freedom to look at what they want, and in what order the they want, and they can appreciate the context of what they are seeing – the only thing we don't give them is the rain!

Virtual Skiddaw then led to an InnovateUK funded project with the OU, the Field Studies Council and DesignThinkers to develop Fieldscapes, and by extension Trainingscapes.

- Lesson Creation

One of the key features of Trainingscapes is that it separates out the technically complex task of creating the 3D models of locations and objects from the pedagogically creative task of creating the learning experience. Whilst we (or a third party) would typically develop any bespoke 3D assets (and the systems come with a good set of generic locations and objects), we would aim to train your eLearning development team, tutors, educators and subject matter experts in how to use the learning authoring system, so that after some initial co-creation of the first lessons you can take complete ownership of the learning content. There is even a drag-and-drop authoring tool for conversations with NPCs so students can explore the inter-personal dimensions of a task as well. The system is very easy and intuitive to use, and we find that most people can create a simple lesson after only an hour's self-guided tutorial.

A screenshot of the forms driven editor is shown below.

- Exercise Player

The exercise player includes lots of the core functionality that any immersive learning exercise needs, such as:

- User logon
- First or third-person (avatar) navigation
- Avatar outfit selection
- Scoring
- Tutorials
- Help
- Logging and audit

The exercise author or tutor can decide whether users experience the exercise as a solo task – they only see themselves – or as a multi-user task – they see other students from the same class. In multi-user mode student can use text-chat and voice chat to communicate and collaborate on completing a task. You can even have the tutor in-world as an avatar as well, leading or watching the class, and in these cases the tutor has a range of controls to help manage the class – like

bringing all the avatars back to them, and then locking them in place!

Trainingscapes has a complete Wiki at https://dadenwiki.atlassian.net/wiki/spaces/FIEL/overview that explains how the whole system works, including authoring, and there are also videos on our YouTube channel at https://www.youtube.com/watch?v=03CAqdjK718&list=PL-LNFntg7mAY6SDxt7hpVO4HqgaEv9VEi (Search "Daden Media").

Web-based Access

One of the holy-grails of immersive learning (and of virtual worlds in general) has been delivery direct to the web browser.

With the emergence of WebGL we are getting a lot closer to that goal. WebGL is the standard for 3D graphics in browsers, and is now present in all current browsers, both desktop and mobile.

However, the size of the 3D models (particularly terrain models) that we use in most of our immersive learning exercises are a bit beyond what most WebGL browsers can cope with – WebGL just isn't as efficient as a graphics library like DirectX.

Also talking to many organisations, particularly schools, we found that they preferred applications to be downloadable to the desktop as they could then better manage them through a central IT system and desktop images. The rise in tablets and apps downloaded from an appstore or side-loaded by the ICT department has also lessened the importance of browser-based apps.

However, in the medium-term we do expect WebGL to be a viable way of delivering immersive learning, and our PIVOTE based applications. In fact PIVOTE was always designed so that you could play the same exercise in radically different technical environments.

We'll keep you posted on our WebGL developments, and would hope to have something in this space during 2020.

- Platforms

Trainingscapes management and authoring work on both PC and Mac computers. The student app works on PC, Mac, Android and iOS smartphones and tablets. We currently support the Oculus range of VR headsets, and will add HTC shortly. See the sidebar for a discussion about web access and a comparison of the different types of VR headset. For us the Oculus Quest is a real game changer, an affordable and completely self-contained unit that can be used almost anywhere with high reliability and good safety.

- Pricing

Up to date pricing information for Trainingscapes is available on our web site. We typically charge an initial set-up fee, plus any exercise creation costs (see earlier for guidelines), any training costs, and then use one of the following:

- **Per student/trainee per year pricing.** We only start charging when a trainer or educator wants to provide access to a lesson to students. Their organisation is charged an annual licence based on the tiered number of trainee accounts they need on the system.

- **An annual usage and support fee** which is scaled based on the level of system use (effectively the number of exercise downloads).

Engagement Model

Where can you use VR?

Immersive training and VR can be used in almost any sector, and in a wide variety of different roles within an organisation.

Within an organisation you can use immersive learning for onboarder training and site familiarisation, for health & safety, customer relationship training, inter-cultural and language training, management and team skills development, business continuity and emergency management, and a wide range of sector specific skills.

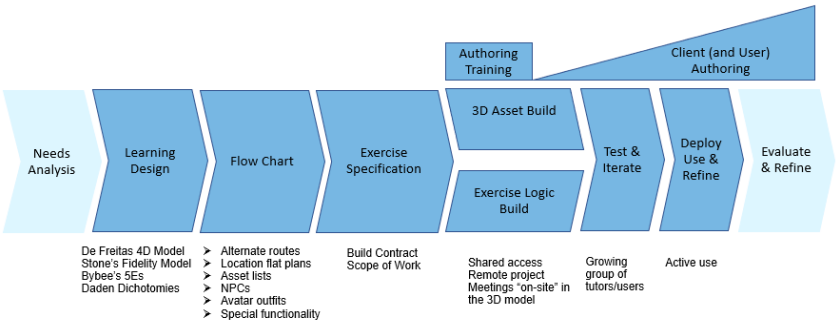
Whilst there is no sector which we think wouldn't benefit from immersive learning we have see great opportunities to improve training in the following sectors:

- Health and care
- Construction
- Social services
- Maintenance
- Emergency Services
- Education
- Land Industries
- Oil & Gas
- Utilities
- Transport
- Defence

Overall immersive learning works best when training what you can't teach (well) in the classroom, or which is inefficient, dangerous or too costly to do for real.

With over 15 years of experience of delivering immersive learning projects we have a well-developed engagement model. If this is your first immersive-learning project there is a good chance you won't know what you really need (as opposed to want) until your users first use it, so we encourage an iterative approach, with co-development and early sharing between our developers, your staff and your users. And since this is all taking place in a virtual world we can even meet with you and hold project meetings on the platform and in the exercise itself!

Informed by approaches such as ADDIE [SOTO2013], Agile [MATTIOLI2015] and SAM [JUNG2019] our standard engagement and project model is shown below, and we can do as much of the upstream and downstream tasks as you need – and quiet honestly if you know what you're doing we're quite happy to just provide licences and support!



It's hard to give a timescale for a generic project, but a typical outline for a bespoke project might be:

- 1-2 weeks capture of current information, lessons and assets
- 2-4 weeks iterative design
- 4 - 6 weeks development
- 1-2 weeks internal test and refinement
- 2-4 weeks client test and refinement
- Implementation/Pilot course
- Assessment and further refinement
- Roll-out

This is saving something like 8 – 16 weeks over a completely bespoke development as Trainingscapes has all the core functionality built in, and the authoring environment offers high productivity than native Unity3D coding – and all that save time can go into creating a better learning experience.

Mobile Learning

An increasing amount of both formal and informal learning takes place and mobile devices, and so immersive learning needs to be available on these as well as desktops and laptops if it is going to be truly successful.

Only 5 or 10 years ago getting a decent immersive learning application (or virtual world, or first-person shooter) on a smartphone was just not viable, but that has all changed now.

Trainingscapes can deploy almost any immersive learning lesson to a tablet or smartphone in the same way as it does to a desktop or laptop. Trainingscapes even caches exercise to the user device (PC, smartphone, tablet, VR), and so once downloaded the user can use the exercise from any location, even without mobile or wifi coverage.

There *can* be issues of memory and performance, so you may be better off using slightly lower resolution 3D models, or reduce some location detail, but the structure of the learning, and the student interactions are identical.

It is a good idea though that if you are expecting users to make regular use of a lesson when mobile to take this into account in the lesson design, or even clone the desktop lesson and then tweak it for mobile use.

When designing for mobile use it is worth considering the following points:

- Mobile learning sessions tend to be short, or interrupted, so keep lessons bite-sized, maybe only 5-10 minutes.
- Text can be harder to read on a smartphone screen, so keep text to a minimum, or even consider using more audio (they're bound to have headphones in anyway!)
- Keep interactions simple as the screens may be small and the device may be unsteady due to a standing user or bouncy bus!

Mobile learning does though offer up some unique opportunities:

- Using the immersive environment to revise/learn tasks immediately before they need to be done in the real world
- Using the immersive environment to explore the history of the site or location around you
- Stand in the physical location whilst using the virtual environment to test ideas and plan for future activities

For a more in-depth consideration of this topic please download and read our Mobile Immersive Learning white paper.

Mobile Devices

Here are some examples of Trainingscapes running on mobile devices.

Basic hand-held use of Trainingscapes on a smartphone.

Close-up of Trainingscapes Mobile UI, showing the virtual joystick for avatar movement on the left, and controls to sprint and fly on the right.

Avatar selection on a smartphone.

Virtual Reality Learning

The rise of Virtual Reality has certainly given virtual worlds and immersive learning renewed interest. However, we are very much of the view that VR is likely to be a minority experience for a long time to come, and even if VR were all pervasive then there are a lot of use cases (such as the mobile learning ones listed above) where the use of VR would still not be the preferred approach. So for us it is very much a case of 3D first, VR second. You should be able to use all our systems with an ordinary PC or tablet or smartphone, but if you do have a VR headset available then you should also be able to take advantage of that and use it when you want to.

There are definitely pros and cons to using a VR headset though. The pros are:

- It certainly heightens the sense of immersion
- You get a better sense of object scale
- Handheld controllers and audio ramp of the immersion even more
- The headset plays in well to simulations where you would have a headset in real life (space, fire, underwater)

The cons though include:

- Many people still get motion sickness in VR
- Most people will be uncomfortable using VR for much more than 60 minutes, probably even 30 minutes
- You need a physically safe location, and probably a minder, unless you are seated
- Sitting in real space whilst standing and moving in VR space is odd
- It is hard to read much text, and very hard to enter much text

So there is a lot to think about. And like mobile, whilst any PIVOTE exercise will work in VR by default you probably need to optimise the exercise for the VR experience, such as by reducing the amount of text displayed and possibly reconsidering how you move around.

PIVOTE currently (Feb17) supports Oculus Rift, and we expect to have Google Cardboard support on Android in 2Q17, with iOS Cardboard, Samsung Gear VR and HTC Vive support to follow later in 2018.

For a more in-depth consideration of this topic please download and read our Virtual Reality for Immersive Learning white paper, and our Virtual Reality – Without the Hype white paper.

VR Devices

The type and variety of VR devices seems ever increasing, here is a quick guide.

- Phone Holders

Google Cardboard is cheap (<£10), but you need to supply your own smartphone. Limited interactivity so really only good for fairly passive experiences.

- Tethered Headsets

Costs are falling (~£400) but you still need to connect to a beefy (£1000+) PC. Best experience, but may well be overkill now for most training needs. Oculus Rift and HTC Vive are the prime examples.

- Integrated Headsets

Self-contained, cheap-ish (£300-400), with controllers and the latest versions (Oculus Quest) has 6DOF sensor-less tracking – could be the ideal device for training.

Who are We?

Daden Limited (www.daden.co.uk) is an immersive learning and visualisation solution provider. We enable our clients to use innovative new technologies to deliver real business benefit, whether that is through more efficient and effective training or using immersive visual analytics to make better decisions. We have been working with immersive worlds and artificial intelligence technologies for over 10 years, and our clients include Government departments and agencies, city and local councils, educators and health providers and private sector organisations in the UK and abroad. We are based in Birmingham, England.

What Next?

If you would like to see more of our work then visit our web site (www.daden.co.uk) where we have links to many client projects and videos.

If you would like a demo of Trainingscapes – delivered face-to-face or via the web – or to discuss how we can help you with your training or learning needs then please contact us:

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Glossary

3DOF	3 degrees-of-freedom, headset tracks head rotation and up/down, but not translation
6DOF	As 3DOF but now 6 degrees, so headset tracks as you move around a space and "peer-in" or "crouch-down"
Avatar	A visual representation of the student
HMD	Head-mounted display, what you put on to experience VR
LMS	Learning Management System
NPC	Non-player character, an avatar controlled by the computer
Tin-Can	An emerging eLearning API
SCORM	An established eLearning standard
SVR	Social Virtual Reality
Unity3D	A leading 3D game engine
VLE	Virtual Learning Environment (as LMS - nothing to do with 3D or VR)
VR	Virtual Reality
VW	Virtual World
xAPI	Experience API (another name for Tin-Can)

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