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.

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. By Immersive Learning Environments we do not mean:

- Virtual Learning Environments (VLEs, which in the USA are normally called Learning Management Systems – LMS)
- Virtual Worlds per se, which are just a subset of the range of Immersive environments and experiences available to us
- Virtual Reality systems with head-mount displays, CAVEs or haptic interfaces – although again all could form part of an immersive learning system.
- Games - although the technology behind games is what drives most immersive learning environments
- Serious Games – although we can create such experiences within an immersive learning environment

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.

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 (eg 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.

- 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 (eg 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 – ie 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 vs eLearning

<table>
<thead>
<tr>
<th>Advantages</th>
<th>eLearning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial awareness</td>
<td>Simple to create and deliver</td>
</tr>
<tr>
<td>Team working</td>
<td></td>
</tr>
<tr>
<td>Social engagement</td>
<td></td>
</tr>
<tr>
<td>Reality</td>
<td></td>
</tr>
<tr>
<td>Encoding specificity</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Challenges</th>
<th>eLearning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost, time and carbon</td>
<td>Higher engagement, superficial understanding</td>
</tr>
<tr>
<td>Practicability of doing in the field</td>
<td>Poorly suited to spatial and social subjects</td>
</tr>
<tr>
<td>Near complete loss of realism when done in the classroom</td>
<td>No encoding specificity</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Immersive Learning Benefits</th>
<th>eLearning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retain most of the advantages of physical learning within a classroom or remote/single user session</td>
<td>Higher engagement</td>
</tr>
<tr>
<td>Avoids expenses of cost/time/carbon</td>
<td>Different pedagogic models (eg exploration)</td>
</tr>
</tbody>
</table>

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:

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

<table>
<thead>
<tr>
<th>Project</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triage Trainer (Blitz Studio)</td>
<td>28% vs 7% for tagging accuracy for simulation trained students [DEFREITAS2009]</td>
</tr>
<tr>
<td>Imperial College Operating Theatre Familiarisation and Training Ward</td>
<td>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]</td>
</tr>
<tr>
<td>Loyalist College Border Crossing Trainer -</td>
<td>Success scores raised from 56% to 98% in one year [LINDEN2009]</td>
</tr>
<tr>
<td>St George’s Paramedics</td>
<td>80% students said will help them to manage patients, 100% saw it as a relevant resource for field/clinical work preparation [PREVIEW]</td>
</tr>
<tr>
<td>University of Colorado Meta-Analysis</td>
<td>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.” [SITZMANN2011]</td>
</tr>
</tbody>
</table>

### Area

<table>
<thead>
<tr>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Businesses and Organisations  Sector Specific Skills</td>
</tr>
<tr>
<td>Business Continuity &amp; Emergencies</td>
</tr>
<tr>
<td>Onboarder &amp; Site Familiarisation</td>
</tr>
<tr>
<td>Health &amp; Safety</td>
</tr>
<tr>
<td>Customer Care &amp; Relationships</td>
</tr>
<tr>
<td>Inter-cultural &amp; Language Training</td>
</tr>
<tr>
<td>Management, Leadership and Team Skills</td>
</tr>
</tbody>
</table>

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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 is designed to be accessed through the web browser, but we have also made downloadable, iPad and Android versions, and even one for the Oculus Rift.
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:

<table>
<thead>
<tr>
<th>Approach</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploratory</td>
<td>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].</td>
</tr>
</tbody>
</table>

**Choosing an Immersive Environment**

We deliberately didn't want to make this paper platform specific, or even all about which platform to choose. That said clients are always after advice as to which technology to use. We identify 5 broad types of immersive learning platforms:

- **Game engines**, which provide the platform to create an immersive environment, but typically need specialist code and content development – such as Unity3D. These are our preferred route for most projects, as they are highly customisable but also very robust and deployable solutions.
- **Sector specific immersive training environments** such as VBS2 and Clinispace, which sector specific assets and formats with a greater or lesser degree of client authoring, but typically at the expense of customisation and cost.
- **Public virtual worlds**, such as Second Life and Cloud Party, which allow immediate use but can have real deployment issues.
- **Private virtual worlds**, such as OpenSim and OpenWonderland, which solve the privacy issues of public virtual worlds, but need more management and still have deployment issues.
- **WebGL technologies** such as three.js and GOO Engine, which in the future may allow game engine like solutions but running natively in the browser.

These categories are not hard and fast, and are definitely blurred at the edges, and all offer differences in flexibility, the need for specialist expertise, deployability, cost etc.

We have a separate short monograph on Comparing Platforms if you want to read more.
<table>
<thead>
<tr>
<th>Approach</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structured</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Task</strong></td>
<td>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 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).</td>
</tr>
<tr>
<td><strong>Assessment</strong></td>
<td>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.</td>
</tr>
</tbody>
</table>

### 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-or, 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.

- 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 take. 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.

- **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!

- 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

In immersive learning there are a lot of traditional design methodologies that we can adopt, as well as some more specific to immersive environments.

They also identified 5 types of simulation: serious games, systems models, modelling tools, role-play simulations and scenario simulations.
- Think about the overall design of the learning process (immersive or not) – Bybee’s 5E and Merri’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:

<table>
<thead>
<tr>
<th>Engagement</th>
<th>Object, event or question used to engage students. Connections facilitated between what students know and can do.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration</td>
<td>Objects and phenomena are explored. Hands-on activities, with guidance.</td>
</tr>
<tr>
<td>Explanation</td>
<td>Students explain their understanding of concepts and processes. New concepts and skills are introduced as conceptual clarity and cohesion are sought.</td>
</tr>
<tr>
<td>Elaboration</td>
<td>Activities allow students to apply concepts in contexts, and build on or extend understanding and skill.</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Students assess their knowledge, skills and abilities. Activities permit evaluation of student development and lesson effectiveness.</td>
</tr>
</tbody>
</table>

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. |
We normally assert that immersive environments are all about tasks that have spatial and/or social components, so doing a project about accountancy was somewhat of a surprise.

Working with the University of Central Florida we helped to create a learning exercise which represented accountancy concepts such as debits and credits in physical way – typically as tanks of “water”. This enabled students to better grasp what was being taught as they could actually see the transactions – rather than just interpret numbers or equations.

The learning space itself was also multi-user, which added a social dimension to the learning.

In addition to the learning space we also created a communications gateway from the in-world chat system to SMS, so that student could message tutors even if the tutors were not in world, and the tutors could reply without having to log back in.

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

- 4D Model

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

<table>
<thead>
<tr>
<th>Learner Specifics</th>
<th>Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learner profile</td>
<td>Fidelity (Environment, Task, Interaction)</td>
</tr>
<tr>
<td>Role</td>
<td>Interactivity (how much, freedom, logging)</td>
</tr>
<tr>
<td>Competencies (inc IT/Gaming)</td>
<td>Immersion (sound, emotion)</td>
</tr>
</tbody>
</table>

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

- 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:

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

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:
**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!

To ensure that the feature NPCs can have useful conversations with the learner, and can act and respond in appropriate ways, 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.

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**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 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.
- **Can you change the desktop?** Many corporate IT environments prevent you from installing new software on the desktop. The simplest way round this is to use a web based system. Unity3D lets us create both downloadable and web based versions of the same training exercise.

**- 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 do 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. The main cost drivers and their potential impact on costs are summarised below:

- **Visual Environment**

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

- **Learning**

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

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

**Project Design**

Designing, developing and delivering immersive learning exercises is still a challenging task, although as we see more and more usage of the technology within different domains, and we as individual companies deliver more and more projects, we are getting a far better handle on how to design and deliver a successful project.

One of the biggest challenges is that for most of our customers it will be their first immersive learning project, and so often a) they don't really know what they want until they see it, b) their assumptions about what is easy and what is hard to do are often flawed, and c) a lot of decisions are very aesthetic, and easy to get hung up on.

We try and educate our clients as best as possible to help them understand what an immersive project will be like. We can give them use of demonstration environments so that they can immerse themselves, we can show them what the art of the possible is, and where the cost drivers will be, and we can use storyboards and 2D techniques as much as possible to refine the look and functionality of a project before we start cutting code and laying virtual bricks.

We can also make use of established eLearning design methodologies to drive the project process, the two most common being ADDIE (a more traditional “waterfall” approach) and SAM (a more modern agile approach). In reality most projects use some combination of the two.

- **ADDIE**

ADDIE is a common model in Instructional Systems Design and it just as applicable to an immersive learning exercise.
The main steps are:

- Analysis: Users, skills, needs, requirements, context
- Design: Learning objective, formats, exercises, blending
- Develop: Prototype, review, enhance, pilot
- Implement: Roll-out, observe
- Evaluate: feedback, assess, behaviours, results

(Kirkpatrick)

The more projects we do the more time we find ourselves spending on the Analysis and Design phases to make sure that what is developed will really make a difference, and the more work that the client has done at the Analysis stage, and even the Design stage, before engaging the better. We are also dependent on our clients to ensure that the long-term evaluation takes place to prove the benefit of the intervention.

Soto [SOTO2013] has an interesting review of instructional design models – and in particular ADDIE – within the context of immersive environment design.

- SAM

The Successive Approximation Model is a lot closer to the way that we have traditionally worked in virtual world environments, where development is shared with the client almost every step of the way. Under SAM there is an initial preparation phase, but
then an iterative design phase, sharing successively more refined prototypes with the client. Once that is complete the project then moves into an iterative build phase, developing and evaluating versions through alpha and beta releases, cycling back to design if necessary until reaching a gold release.

We use storyboards and GUI design tools such as Balsamiq to support the iterative design phase, helping the client refine and detailed functional requirement and design, with the aim of signing that off before moving into the development phase. Here any requirement to cycle back into design is then picked up through change control.

- AGILE

The most “open” project management approach which we’ve used on a few projects is the Agile approach. Here we start with a list of requirements, work with the customer to select the first ones to tackle in the first “sprint” (typically 2-4 weeks), and then develop those. At the end of the spring we review, update the requirements list with any new ones that have emerged from experience with the first sprint, re-prioritise, and then select the targets of the next sprint. The project then continues sprint by sprint until we reach the point where all the key functionality is there for a release (often also managed through a time/cost box).

This model works well for more exploratory environments – where there are lots of features you’d like to add in, and you also need to know what it feels like before deciding what will work best.

Of course the models do not need to exist in isolation, and its perfectly possible (with care) to combine elements of any 2, or even 3. For instance a Phase 1 might be done with ADDIE to get the core functionality in, but a Phase 2 with AGILE to develop added features.

- Project Plan

It's hard to give a complete template for a project plan, but a typical outline might be:
- 1-2 weeks capture of current information, lessons and assets
- 2-4 weeks iterative design
- 8 – 16 weeks development
- 1-2 weeks Daden Factory Acceptance Test and refinement
- 2-4 weeks client User Acceptance Test and refinement
- Delivery
- Implementation/Pilot course
- Assessment and further refinement
- Roll-out
Trainingscapes

Trainingscapes are Daden’s immersive learning environments developed to meet your training needs. Drawing on our extensive experience of creating immersive learning exercises for a wide variety of clients in the UK and abroad, Trainingscapes can provide a variety of engaging, immersive experiences for your users, delivering the features and benefits described in the preceding pages.

The base for a Trainingscape is a default set of immersive learning functionality, the things we know that you are bound to need, and which saves you from specifying them in detail or paying for the bespoke development – although we are always happy to customise them or go down the bespoke route if that is what your project needs. The functionality covered by this core includes:

- User logon
- Multi-user (optional), inc. text chat, avatar visibility
- First or third-person (avatar) navigation
- Click to focus navigation
- Avatar selection (optional)
- Simple scoring
- Simple countdown timing
- Tutorial
- Help
- Logging and audit
- 2D management application (web or PC) to control: Accounts, Users and 2D content

On top of the core we then develop the 3D environments and learning functionality that you need for your training experience. The typical features implemented at this stage are:

- 3D environment to suit subject and at appropriate level of detail
- Training tasks developed to your pedagogy and specification
- Avatar and avatarless scenes
- 2D, 2.5D and 3D scenes
- Role specific avatars (optional)
- In-world building (optional)
- Exercise authoring (in-world or 2D app)
- VLE/LMS integration (also SCORM and Tin-Can API)
- Closed and open user groups for multiple users
- Student registration validation

Trainingscapes can be delivered to a PC/Mac web browser or as downloadable/installable applications on a desktop computer, or, as Mobilescapes, equivalent environments can also be delivered on iPad or Android tablet devices.
For more information on Trainingscapes please contact us at info@daden.co.uk.

**Who are We?**

Daden Limited ([www.daden.co.uk](http://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, where we have links to many client projects and videos.

If you would like a demo of our Trainingscapes or Mobilescapes – 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:

- By phone on +44 (0)121 250 5678
- By email to trainingscapes@daden.co.uk
- By twitter at @dadenlimited
- By post to:

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  Birmingham
  B7 4BB
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