Virtual worlds are authentic sites for learning

1 Abstract

This study investigates how 'meaningful learning' can be understood in the context of knowledge-age skills. It also investigates whether terms such as 'authentic', 'active' and 'collaborative' can be applied to individual students are sitting on their own in front of computers. It then considers whether students employ higher levels of knowledge-age skills in meaningful learning environments. Finally, it asks whether the distinction between meaningful and non-meaningful learning environments is more important for the development of knowledge-age skills than the distinction between formal and informal situations or between staff-run and student-run situations.

2 Introduction

Introduction should lead up to these points, which are the conclusion:

- Students display more knowledge-age skills when learning experience is meaningful.
- A meaningful learning situation is active, authentic, constructive, cooperative and intentional.
- We have selected eight sessions from Schome when learning could be expected to take place.
- For each session we have analysed the input of one student for evidence of knowledge-age skills.
- If the learning situation is meaningful, they demonstrate higher levels of knowledge-age skills.
- The same student will demonstrate higher levels in a more meaningful situation.
- We expected the distinction to be formal/informal or teacher/student run – but it is not.
- Other important elements are learner control, multimedia, collaboration and time.

2.1 Schome

This research was carried out within the Schome community, a group established with the aim of creating 'a new form of educational system designed to overcome the problems associated with current education systems in order to meet the needs of society and individuals in the 21st century' (Sheehy, Ferguson, & Clough, 2007). In 2007, the community opened a project in Teen Second Life, intended to provide a group of 150 school students across the UK with a valuable learning experience that would extend their formal school activities. One of the goals of this project was to investigate to what extent these students would develop knowledge-age skills within this environment. Note that the Schome ethos involves a blurring of the dividing lines between students and teachers. This article uses the age division imposed on educators working in Teen Second Life: 'student' is used to refer to participants aged 17 and under, while 'staff' is used to refer to all participants aged 18 or over.

The Schome Park Programme is described in detail elsewhere in this book (add refs). Learners were based on the Teen Second Life island of Schome Park – which was later developed to become a small archipelago. The Schome Park islands were open from February 2007 until May 2008. During the first, three-month phase of the project, students from across the UK were encouraged to join one of three subject strands: Archaeology (run by lecturers from Liverpool University), Ethics and Philosophy (run by a lecturer from Warwick University) and Physics (run by staff from The National Physics Laboratory). Each of these strands involved regular sessions including talks, discussions and activities. The second phase gave more control to learners and, in addition, included a class of participants from the east coast of the US; while the five-month final phase included a more formally organised media class from the US west coast.

Although the Schome Park Programme was based in the virtual environment of Teen Second Life during this period, it also made use of a range of other Web 2.0 technologies – most notably a wiki and forum.

To understand and assess this environment, it is important to consider interaction in world, in the wiki and in the forum (Schome Community, 2007).

2.2 Knowledge-age skills

Throughout the first three phases of the Schome Park Programme (February 2007-May 2008) the learning focus was on developing knowledge-age skills. The term 'Knowledge Age' is used to designate the period of history since 1991, in which knowledge – rather than land, labour or capital – has been the key wealth-generating resource (Savage, 1996). During this period, constant change in society has become the status quo, and it is increasingly difficult to predict which skills and knowledge will be useful or essential in the future (add ref: Jean-François Lyotard, The Postmodern Condition, 1979, Manchester University Press).

According to Guy Claxton:

> If the main thing we know about the future is that we do not know much about it, then the key responsibility of the educator is to not to give young people tools that may be out of date before they have even been fully mastered, but to help them to become confident and competent designers and makers of their own tools as they go along. (Claxton, 2002)

There have been many attempts to identify the key skills that will allow students to become confident and competent designers and makers of their own tools in this knowledge age. Trilling and Hood identified a set described as the 7Cs: critical thinking-and-doing, creativity, collaboration, cross-cultural understanding, communication, computing, career and learning self-reliance (Trilling & Hood, 2001). The Partnership for 21st Century Skills (2002) identified a set of learning skills which they divided into three subsets: information and communication skills, thinking and problem-solving skills, interpersonal and self-directional skills.

The Schome Park Programme drew on these ideas when it produced its own Knowledge Age Skills Framework. The Framework focuses on a set of key skills that can be applied in almost any situation. Despite the virtual world setting of Schome Park, none of the skills is dependent on technology – each is equally relevant in the virtual world and in the physical world. The Framework also contains assessment criteria for each of these skills, making it possible to demonstrate progression from Level 1 to Level 4. Again, these assessment criteria are not tied to resources – creativity is not limited to facility with pen, paint or instrument, and communication is not linked to the use of specific mediating technologies.

	Level 1	**Level 2**	**Level 3**	**Level 4**
Communication	Selects and uses structures, styles and registers appropriately in a range of contexts. Listens with concentration and understanding.	Adapts communication for a range of settings and audiences.	Makes a range of contributions, demonstrating perceptive listening.	Takes a leading role, initiating and sustaining conversation, and reflecting understanding.
Confidence	Works on small projects, responds to the advice of others.	Initiates own projects. Offers opinions and advice.	Responds to challenges; engages in debate.	Works to improve the confidence of others, while maintaining their own.
Creativity	Questions and challenges.	Makes connections, sees relationships.	Envisages what things might be.	Reflects critically on ideas and practice.
Leadership	Understands and sets greater goals	Sets examples,	Recognises skills	Applies own and others' skills

	and purposes.	explains.	of peers.	productively.
Motivation	Participates when encouraged to do so. Engages in activities organised by others.	Suggests new activities unprompted; voluntarily takes some role in organising activities.	Takes the initiative and organises activities in which others can participate.	Takes responsibility for motivating others.
Problem solving	Identifies problems and invites solutions.	Proposes solutions to their own problems and those of others.	Works to develop solutions to problems.	Identifies deep-rooted or long-term problems and works with others to solve these.
Teamwork	Projects personal characteristics.	Receives messages from others, shares goals. Develops processes.	Values others, understands roles and changes in roles.	Joint problem-solves. Manages relationships.

Figure 1: Schome Knowledge-Age Skills Framework and associated assessment criteria.

2.3 Meaningful learning

The experimental nature of Schome meant that students were able to deploy and develop their knowledge-age skills in a range of situations. The class of US media students, for example, was engaged in assessed, formal learning in a new setting with a wide range of resources. At the other end of the spectrum, students who had never met in the physical world worked in their own time to design their own environments and experiences together. Sessions on a range of topics were organised by both staff and students during all phases of the programme. Formal and informal groupings of staff and students formed to work on different projects. There was therefore a very wide range of approaches to teaching and learning. All of these, were linked to the social constructivist view that 'learning is an active process of knowledge building during which learners construct new understanding together based on their existing knowledge, developing new 'knowledge and skills through practice within a supportive group or community' (Sharples, Taylor, & Vavolua, 2006, p223). From this perspective, the process of knowledge construction is both a personal endeavour and a socially mediated one. Because of this, effective learning is not generated through passive consumption of content, but takes place more effectively through the social construction of knowledge as played out through interactions with others.

The Schome Park Programme provided a wide range of opportunities for the social construction of knowledge, and for joint development of items as varied as islands, governments, regattas and laws of physics. However, it was not clear which situations would best support practise of knowledge-age skills. The ethos of Schome, with its move away from classrooms, implied that informal learning experiences would be particularly productive. In-world experience on the project suggested that student-run initiatives would require more use of knowledge-age skills than staff-run initiatives.

What was clear was that it was important to produce learning that would be meaningful to participants. Meaningful learning is often contrasted with rote learning (Ausubel, 1963) and has been defined as 'learning in which new experiences are linked with information already stored in long-term memory' (Grabe & Grabe, 1998, p430). Jonassen et al. (2003), proposed that meaningful learning occurs when students are actively engaged in making meaning. They broke down the definition of meaningful learning into five interdependent yet interacting attributes, it is active, authentic, constructive, cooperative and intentional.

Attribute	Description

Active (Manipulative/Observant)	Learners develop knowledge and skills in response to their environment, manipulating objects and observing and learning from the results.
Authentic (Complex/Contextualised)	Learning is more effective when situated in a meaningful context rather than being oversimplified and presented in isolation.
Constructive (Articulative/Reflective)	Learners reflect on activity and observations and articulate what they have learned. Thus when new experiences appear contradictory, they can engage in a meaning-making process to develop their mental models and make sense of their observations.
Cooperative (Collaborative/Conversational)	Collaboration is a natural human activity, with most collaboration taking place through conversations. Collaborative learning relies on socially negotiated understandings that help learners build on and learn from their own and each others' knowledge to construct new knowledge.
Intentional (Reflective/Regulatory)	People think and learn more when they are motivated to do so in order to achieve a cognitive goal. Technologies should engage learners in articulating what they are doing; decisions made, strategies chosen and answers found, thereby enabling them to use their constructed knowledge in new situations.

Figure 2: Elements of meaningful learning,:
from Jonassen, D. H., Howland, J. L., Moore, J. L., & Marra, R. M. (2003)

This study investigates how 'meaningful learning' can be understood in the context of knowledge-age skills. It also investigates whether terms such as 'authentic', 'active' and 'collaborative' are applicable when individual students are sitting on their own in front of computers. It then considers whether students employ higher levels of knowledge-age skills in meaningful learning environments. Finally, it asks whether the distinction between meaningful and non-meaningful learning environments is more important for the development of knowledge-age skills than the distinction between formal and informal situations or between staff-led and student-led situations.

3 Data

The Schome Park islands in Teen Second Life were open for 18 months. During that time, staff logged chat whenever they were in world – saving automatically generated transcripts of all conversations to which they had access. This data was supplemented by extensive activity in the project's forum and wiki, as well as photos, videos, published notes, blogs and a variety of other evidence including in-world scripts, designs and artefacts. From the thousands of hours of online activity, eight events have been selected for analysis. Each of these is well documented, each was a planned event and each was advertised in advance. In other respects, they differ considerably, for purposes of comparison. Staff ran four sessions and students ran (but did not necessarily initiate) the other four, as shown in Figure 3. Each of these groupings contains events from early in the project and others from late in the project. The student-run Time Explorers session can be compared with the staff-led Archaeology session, as Time Explorers was set up to be a history and archaeology series to replace the Archaeology strand. The two student-run weddings are also comparable. However, Wedding 2 is the most formal session studied, as students were required to work in pairs to organise an in-world event, and their event was assessed, as was the subsequent video in which they reflected on their experiences. Wedding 1, by contrast, was the

least formal session studied – it was organised by a group of students, part of it involved a surprise party for staff, and there were no stated learning intentions.

It can be difficult to define where these events begin and end. The subject strands – archaeology, ethics & philosophy and physics – ran for several weeks, often building on work in previous sessions. The second wedding was part of a series of class presentations, the first wedding occupied students for several days, and the regatta was one of several organised by the same students. In each case, analysis has been confined to the event itself, preparation and discussion specifically related to that event, and reflections related to that event. Even this focused approach includes a wide range of data, including chat logs, forum threads, wiki pages, photographs, videos, lecture transcripts and in-world artefacts. Despite the amount of data collected, a complete record is not available. Elements of the planning of Wedding 1 were consciously kept hidden from staff, while much of the planning for Wedding 2 took place in a face-to-face setting. Although the chat logs for strand sessions appear complete, staff had no access to conversations held between other participants by instant message in world.

As each event involved a variety of people, analysis in each case focuses on the student who was most active within it. In the case of the student-run events, this was the student who took the lead role in organisation. In the case of staff-run events, the student whose word count in the associated chat log was highest was judged to be the most active. Wedding 2 was organised jointly by Silvermist and Qwin, neither appeared to have taken the lead, so the contributions of both were analysed. Trix and Topper were each the most active student on two occasions, so their use of knowledge-age skills in different settings can be compared.

Staff run	
Archaeology	Date 2 April 2007 One of a series of staff-run archaeology sessions. Discussion of the subject: Should the Elgin Marbles be returned to Greece? Three students and two staff members actively participated. Relevant data includes a staff chat log of the session, and the session sign-up page on the wiki. Analysis focuses on Trix – the student who spoke the most.
Ethics and Philosophy	Date 20 February 2008 One of a series of staff-run ethics and philosophy sessions. Discussion of the relationship between science and philosophy. Four students and one staff member actively participated. Relevant data includes a staff chat log, the session sign-up page and a forum thread. Analysis focuses on Topper – the student who spoke most.
Mathematics	Date 3 February 2008 One of a series of staff-run maths sessions. General maths discussion, initially focusing on line equations. Six students and two staff members actively participated.. Relevant data includes a staff chat log and the session sign-up page. Analysis focuses on Decimus – the student who spoke most.
Physics	Date 21 April 2007 One of a series of staff-run physics sessions. Lecture on Earth Observation Satellites.

	Eight students and one staff member actively participated.. Relevant data includes a staff chat log, the session sign-up page, a forum thread, a copy of the lecture on the web, including diagrams and hot links, a picture of the session, a linked web page. Analysis focuses on Hapno – the student who spoke most.
Student run	
Regatta	Date 12-14 October 2007 Second of several regattas organised by the same student. Sailing regatta. Numerous students and staff actively participated.. Relevant data includes staff chat logs, forum threads, wiki pages, pictures and in-world artefacts including boats and buoys. Analysis focuses on Topper – the student who took the lead in organising the event.
Time Explorers	Date 19 May 2008 One of a series of history and archaeology sessions that were normally, but not always, run by students. Discussion of Roman roads. Three students and three staff members actively participated. Relevant data includes staff chat logs, a forum page, a wiki page, pictures and in-world artefacts including a cross-section of a Roman road. Analysis focuses on Vibia – the student who took the lead in organising the event.
Wedding 1	Date 5 April 2007 First large-scale event organised by the students: wedding of Trix and Wintermute. Relevant data includes staff chat logs, forum threads, pictures, video footage and in-world artefacts including buildings and clothing. Analysis focuses on Trix – the student who took the lead in organising the event.
Wedding 2	Date 16 April 2008 Event organised by two American students to satisfy the assessment criteria of their media class. Wedding of Silvermist and Qwin (neither had attended Wedding 1) Twelve students and two staff members actively participated. Relevant data includes staff chat log, forum thread, pictures, video footage and in-world artefacts including furniture and clothing. Analysis focuses on Qwin and Silvermist – the students who took the lead in organising the event. Note that although Wedding 2 was run by students, it was initiated by a staff member.

Figure 3: Description of data selected for analysis.

4 Analysis

To identify whether these eight sessions could be classified as meaningful learning environments, reference was made to the five attributes of such environments as identified by Jonassen et al. (2003).

The descriptions of these attributes transferred well from a physical to a virtual setting. Active learning involves responding to the environment and to the manipulation of objects, both of which are important aspects of Teen Second Life. Authentic learning involves a meaningful context. Building a flying car or devising a 'no submarines' rule for a regatta may be unexpected learning activities but in the context of the appropriate sessions they were both judged to be meaningful. Constructive learning in virtual reality included not only the creation of mental models but also, in many cases, actual construction. In the Time Explorers session, for example, one student created a cross section of a Roman road, including textures from photographs that had been taken and uploaded for the event. A missing texture was supplied and added by another student, while a member of staff walked an avatar along the reconstructed road and another took pictures to record the different layers.

The descriptions of the attributes of meaningful learning were modified to clarify how they related to knowledge-age skills rather than to more subject-specific skills and knowledge. To the description of active learning was added 'organising individuals' – an activity that is not often available to classroom students but which is crucial in Schome Park. Under the heading of 'authentic learning' it proved difficult to define what a meaningful context for knowledge-age skills would be. Taking responsibility for 'organising, planning or administering the session' was considered to be evidence that the context had meaning for a student. This involvement in organising sessions was also considered to be important for constructive learning because, in some cases, students did not articulate the knowledge-age skills they had developed, but they put them into practice by organising a subsequent session. Activity was also added to the definition of cooperative learning, as actively working together is an important aspect of collaboration in a virtual reality setting. Finally, the 'cognitive goals' necessary for intentional learning were defined to ensure that they were relevant to knowledge-age skills.

Attribute	Description
Active	Learners develop knowledge-age skills in response to their environment, organising individuals, manipulating objects and observing and learning from the results.
Authentic	Learning of knowledge-age skills is situated in a meaningful context. Learners take responsibility for organising, planning or administering the session.
Constructive	Learners reflect on activity and observations. They express their reflections - either by articulating them, or by expressing them practically in the organisation of a subsequent session.
Cooperative	Learners not only build knowledge together through dialogue, they also actively work together.
Intentional	Learners are consciously working towards goals which involve communication, creativity, leadership, motivation, problem solving or teamwork.

Figure 4: Operationalising the elements of meaningful learning in the context of knowledge-age skills in Second Life.

The eight sessions were then categorised according to the criteria in Figure 4 in order to reveal which provided an environment for the meaningful learning of knowledge-age skills. The differences between the sessions run by staff and those run by students were very marked. Student-run sessions provided opportunities for the meaningful learning of knowledge-age skills, while staff-run sessions did not. The distinction is perhaps clearest in the case of two comparable sessions: Archaeology and Time Explorers. Both involved a familiar educational set-up – a discussion on history facilitated by someone with knowledge of the subject. However, while Time Explorers gave the student leader many opportunities to for the meaningful use and development of knowledge-age skills, the Archaeology session did not.

It must be remembered that this analysis focuses on the development of knowledge-age skills. The staff-run sessions involved learning objectives related to subject-based knowledge and debating skills. If rated for meaningful learning opportunities in relation to these areas, they would have appeared much more positive.

	Arch	E&P	Maths	Physics	Regatta	TimeEx	Wed 1	Wed 2
Active	N	N	N	N	Y	Y	Y	Y
Authentic	N	N	N	N	Y	Y	Y	Y
Constructive	N	N	N	N	Y	Y	Y	Y
Cooperative	N	N	N	N	Y	Y	Y	Y
Intentional	N	N	N	N	Y	Y	Y	Y

Figure 5: Meaningful elements of learning sessions as categorised in Figure 2.

Having classified the eight sessions according to their provision of opportunities for the meaningful development of knowledge-age skills, it was necessary to classify them on the basis of the levels of knowledge-age skills displayed by students. This analysis is presented in Figure 6. Were students are classified at level 0 for a specific skill, this indicates that during the session they showed no evidence of working even at level 1.

	Arch	E&P	Maths	Physics	Regatta	TimeEx	Wed 1	Wed 2
Subject	Trix	Topper	Decimus	Hapno	Topper	Vibia	Trix	Qwin Silver-mist
Communication	3	4	4	4	4	4	4	4
Confidence	3	3	3	0	4	2	2	3
Creativity	2	4	3	4	4	3	3	4
Leadership	2	0	2	0	4	4	4	4
Motivation	1	1	2	1	4	4	3	3
Problem solving	2	4	2	0	4	3	3	3
Teamwork	1	1	1	1	4	4	4	4

Figure 6: Level of knowledge-age skills demonstrated by students according to the scale outlined in Figure 1.

To give a flavour of the analysis and of ways in which students could demonstrate proficiency at knowledge-age skills, we focus temporarily on Topper, who was classified as working at level 4 on all seven knowledge-age skills when he took the lead in organising an in-world regatta in October 2007.

This regatta took place on the evenings of Friday 12 October, Saturday 13 October and Sunday 14 October. The three-day event included six races, a prize-giving ceremony and a post-regatta celebration. In addition, there were planning meetings and training events at which students and staff could learn to sail different boats in world. This event was entirely organised by students, with Topper taking the lead, assisted by Achilles, another student. The event took approximately two weeks to plan, using the resources of the wiki, the forum and Teen Second Life. The organisers also drew on their experience of the first Schome Park regatta, which they had organised six months earlier.

To organise a regatta in world requires the use of a wide variety of Second Life skills, some at an advanced level. The first regatta involved terraforming the island; changing the island's geography to make circumnavigation possible, and temporarily removing several buildings. All participants needed access to boats, and these boats had to be of the same standard, not programmed to move at different speeds. Controlling such boats is not easy, and requires training and practice. While it is easy for avatars to find their way around Second Life by flying or teleporting; remaining at ground level makes navigation difficult. The organisers therefore had to produce and distribute a map of the island, using software to outline the course. On the day, the route had to be explained and demonstrated on several occasions.

In-world communication is difficult when large groups of people are spread across the island, as Second Life's chat line only contains chat from nearby avatars. The organisers experimented with setting up a new group, all of whom could be contacted simultaneously by IM. This proved difficult, as participants arrived and left throughout the event. More successful was the signalling system, scripted to release particles: red to signal two minutes until the start, yellow as a one-minute warning, green to signal the start of the race, black to signal a false start and blue to signal that a protest had been lodged. There was also a scripted timer in use.

Second Life always presents its own challenges. In this case, the organisers had to define a powerboat: 'any vessel that can pass under the bridges whilst floating on the water, NO SUBMARINES!!' They also had to deal with elaborate new forms of cheating, either by changing the scripting (the controlling program) on a boat, using avatar wings as additional sails or, as one Sparker claimed, 'I also saw him hop out of his first boat, fly the course, then hop into his second boat which was minutes away.'

Although the regatta took place in Teen Second Life, a lot of work before and after the event took place in the Schome forum and wiki. These were used to propose dates and times, to publicise and sign up for the event, to display the route, to report the results, to post pictures and write-ups of the event and to work together to solve problems. The skills which were needed to prepare for the event included setting up and editing a wiki page, uploading a picture to the wiki and displaying it there, setting up a new forum thread, uploading a picture to the forum and displaying it there.

Staff chat logs of the second regatta show different students and staff learning different things simultaneously. Some worked on specific Second Life skills, and students worked together on controlling boats, making objects phantom, or using and developing scripts. Meanwhile, staff members were helping each other to increase their camera-control skills, and some students were helping staff to control boats. Other participants were leaving the Second Life environment to create wiki pages and tables or to add to forum threads.

It can be seen that most of the staff and students involved in the regatta were required to use a variety of knowledge-age skills. The analysis in Figure 7 focuses on Topper, and how he demonstrated that he was working on level 4 in each case.

Communication	
Working at level 4 Takes a leading role, initiating and sustaining conversation and reflecting understanding	Initiates and sustains discussion in the wiki, beginning the thread 'The 2nd Schome Park Reagatta' on 29 September Begins a wiki page on 2 October detailing the event and races http://schome.open.ac.uk/wikiworks/index.php/Regatta_2 on 2 October. Modifies this page on seven days in the next month.
Confidence	
Working at level 4 Works to improve the confidence of others, while maintaining their own.	Provides training in the use of boats. Adds a race category designed for builders and encourages a student whose expertise is in-world building to join the race. Encourages a staff member to enter for a race although she is not confident about her boat control.
Creativity	
Working at level 4 Reflects critically on ideas and practice.	Changes the race route in order to reflect changes in the landscape. Encourages people to arrive in time to have the course explained before the race. Produces aerial photo of the island, detailing the race-course. Creates and distributes buoys in world to mark the route.

Leadership	
Working at level 4 Applies own and others' skills productively.	Uses own knowledge of real-life racing. Asks a student who is a confident wiki user to add a table to the regatta page. Organises race, deals with objections and technical issues Gives other students opportunities to take responsibility. Manages administrative issues, for example, tells fellow officers to display their title above their avatars' heads. Explains technical terminology. Clarifies rules.
Motivation	
Working at level 4 Takes responsibility for motivating others.	Publicises the event, solicites comments. Organises rewards in the form of trophies. Keeps the event light-hearted and fun.
Problem solving	
Working at level 4 Identifies deep-rooted or long-term problems and works with others to solve these.	Ongoing problem: in-world sea is cluttered with objects. organises staff and students to identify and remove these. Ongoing technical problems. Ensures there is sufficient flexibility in the event arrangements and staffing for the event to continue when anyone crashes out of Teen Second Life Important issue: marks death of staff member with commemorative trophy.
Teamwork	
Working at level 4 Joint problem-solves. Manages relationships.	Deals with squabbles by ignoring them or by a general request to 'Cool it'. Event continues smoothly whether Topper is on or offline. Evidence of planning discussion having taken place before the event. Organises briefing sessions and training sessions. Organises other Sparkers to run training sessions. Organises race commentary.

Figure 7: Evidence that Topper was working at Level 4 of all knowledge-age skills during the regatta.

5 Discussion

Analysis showed a clear relationship between the sessions in which meaningful learning of knowledge-age skills was possible, and the level of knowledge-age skills demonstrated by students within the sessions. When meaningful learning of knowledge age skills was supported, students consistently displayed those skills at higher levels than when meaningful learning was not supported.

Display of knowledge-age skills also appears to be related to whether a session is staff run or student run. In part, this correlation was determined by the method of analysis, as the session leader was always likely to have to demonstrate more leadership and motivation than other participants, but staff leaders of sessions were excluded from the student-focused analysis. A possible exception to the correlation between staff-run sessions and the demonstration of low levels of knowledge-age skills is the case of Wedding 2. Although this is classified as a student-run event because it was organised and run by student; it was initiated, motivated and framed by a member of staff. It scores highly for demonstration

of knowledge-age skills, but this is more clearly linked to its provision of opportunities for meaningful learning than it is to its initiator.

The analysis also shows that display of knowledge-age skills is not directly connected to formal or to informal learning. Wedding 2 was the most formal of the sessions studied: participants organised the event as part of their school class, they were instructed to work in pairs, to propose and organise an event and then to produce a video critique of that event. Their participation was assessed and a teacher who was present in both their physical and in their face-to-face environment guided them. Organisers Qwin and Silvermist both scored highly on all knowledge-age skills – and their levels were similar to those attained by the organisers of the least formal sessions: Topper, who organised the Regatta and Trix, who organised Wedding 1.

The display of knowledge-age skills was not closely linked to the form of session organisation. Physics, Archaeology and Time Explorers were similar in that they involved an expert taking the lead on the presentation of a previously advertised subject. Ethics and Maths involved group discussion facilitated by an expert, the Regatta was an event run by an expert and both the Weddings were presented to participants as events rather than as learning sessions. Students at events tended to display higher levels of knowledge-age skills than those at learning sessions – but this was not the case with Time Explorers, where the organiser worked at high levels on most knowledge-age skills.

When students ran sessions, those students demonstrated predictably high levels of leadership. Equally predictably, students often demonstrated no leadership at all in staff-run sessions. Less expected were the very low levels of teamwork demonstrated in sessions that allowed little opportunity for meaningful learning of knowledge age skills. Students in these sessions only demonstrated level 1 teamwork skills, a level which requires no more than the projection of personal characteristics. By contrast, where meaningful learning of knowledge-age skills was possible, the students whose contributions were analysed all attained level 4 by demonstrating that they could solve problems together and manage relationships.

Another marked distinction occurred in levels of motivation. In sessions that allowed little opportunity for meaningful learning of knowledge-age skills, students rarely achieved more than level 1 for motivation. Level 1 involves participating when encouraged to do so and engaging in activities organised by others – so would be automatically achieved by a participant. However, where meaningful learning of knowledge-age skills was possible, students all demonstrated level 3 skills by taking the initiative and organising activities in which others could participate, and they were also likely to move to level 4 by taking responsibility for motivating others.

Because the input of both Topper and Trix was assessed in relations to two different sessions, it became clear that students who can achieve very highly on knowledge-age skills only do so when the situation is right. There is no smooth progression and development to be demonstrated. Topper organised the regatta in October 2007 and demonstrated that he was capable of working at level 4 on all seven knowledge-age skills. However, when he participated in the ethics and philosophy session the following spring he demonstrated much lower levels, showing no evidence of leadership and only limited levels of teamwork and motivation. Similarly, Trix achieved high levels on most knowledge-age skills when she organised Wedding 1 but had shown much lower levels of achievement a few days earlier in the archaeology session.

Other elements appear to be connected to the use of high levels of knowledge-age skills. The Regatta, Time Explorers, Wedding 1 and Wedding 2 were all extended events that required days of preparation and that attracted later discussion, analysis or comment. By contrast, Archaeology, Ethics & Philosophy, Mathematics and Physics were sessions prepared by staff. Student participation was limited to the session itself, so lasted an hour or less. This links to the Authentic and Constructive elements of meaningful learning which involve learners in organising, planning and administering sessions as well as in reflecting on them later or organising subsequent sessions. Meaningful learning of knowledge-age skills thus requires some commitment over time.

High levels of knowledge-age skills also appear to correlate with the use of multimedia. Figure 3 shows that data relating to the events rated less meaningful in terms of the development of knowledge-age skills was limited. In the majority of cases it was confined to a single staff chat log, a wiki sign-up page and a short forum discussion. The events rated more meaningful in terms of knowledge-age skills had much more output in a variety of media. Relevant data includes not only staff chat logs, forum threads and wiki pages but also pictures, videos and a range of in-world artefacts. This is connected to the Active and Constructive elements of meaningful learning that requires participants to respond to their environment, to manipulate objects and to reflect on and react to their learning.

A final correlation involves students working together to organise events. Student organisers who displayed high levels of knowledge-age skills always worked in conjunction with others. Qwin and Silvermist, who organised Wedding 2 together, are an obvious example – it is difficult to distinguish who was responsible for which elements of their event. Although Topper took the leading role in organising the regatta, he worked together with Achilles in setting it up and organising it. During the Regatta, Topper had to leave unexpectedly on several occasions, and Achilles was always available to take control at these points. Trix took the lead on Wedding 1, but was helped by a group of students who designed avatars, locations, clothing, accessories and the form of the ceremony. Vibia took the lead on the session of Time Explorers analysed here, but responsibility for strand organisation was shared between a group of students and staff, who collaborated before, after and during the session. This is connected to the Cooperative element of meaningful learning – learners build knowledge together through dialogue, and they also actively work together.

6 Conclusions

To assess opportunities for meaningful learning of knowledge-age skills, it is important to take into account that such learning opportunities are likely to be initiated, organised, run and evaluated by students rather than staff. Students are able to access active, authentic, constructive, cooperative and intentional learning within a virtual reality setting if they are able to interact with others and exercise control over their environment and activities.

Quantitative analysis shows a correlation between in-world sessions in which students display high levels of knowledge-age skills and in-world sessions involving meaningful learning opportunities that are active, authentic, constructive, cooperative and intentional. The same student will demonstrate higher levels of knowledge-age skills in a situation that provides meaningful learning opportunities than in a situation that does not. High levels of knowledge-age skills are also displayed in sessions that are student-run, although not necessarily student initiated. No link was demonstrated between the formality of a session and the knowledge-age skills displayed by participating students.

Qualitative analysis reinforces the conclusions of quantitative analysis. Events during which students display high levels of knowledge-age skills are likely to be run by students, although staff may initiate them. They extend over time and are likely to involve the use of a variety of media. These qualities are closely linked to the attributes of meaningful learning situations.

This study was not able to show whether students develop knowledge-age skills in these environments or whether they merely display skills acquired in other contexts. However, it does indicate situations in which students are likely to encounter others employing high-level knowledge-age skills, and situations in which students have clear opportunities to use these skills.

Within this data set, the majority of opportunities to utilise high levels of knowledge-age skills were within student-initiated activities. However, the example of Wedding 2 showed that it is not necessary to wait for such opportunities to arise spontaneously; teachers in the context of formal education can initiate them.

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