

Tales From a Pod

Vic Callaghan

Essex University, Colchester, CO43SQ, UK
vic@essex.ac.uk

Abstract. In this Science-Fiction Prototyping article, I present an imaginative forward look at how artificial intelligence and virtual environments might change the nature of future education. The discussion is intended to be a somewhat speculative and thought provoking journey into what may be possible. At its root, it imagines a future time when the *technological singularity* has been reached, and machine intelligence and interaction is equal or surpasses that of people. I do this by means of a fictional reflection on how life might be in the future, a set of four small vignettes and a discussion of the factual research inspiring these views.

Keywords. Science fiction prototyping, futurology, intelligent environments

Part A – The Story

1. Background

Life in the mid 21st Century was hard. Despite a quarter of a million people dying every day (3 per second, Megumi Yasu had once calculated!), the population of the world had risen to an all time high of 9 billion by 2043, bringing ever-rising levels of pollution, global warming and food shortages. On top of that, intelligent machines were rapidly displacing people from the world of work! All these factors led Megumi to fear for the future for her son Kenji; how would he survive the intense competition for dwindling resources and jobs. Sometimes it seemed to Megumi that a suffocating darkness had descended on the world, banishing the optimism her contemporaries held for a new age of technologically driven prosperity, leaving only dark visions of a world engaged in a seemingly remorseless struggle for existence. Most parents faced the same fears for the future and had come to a similar conclusion to Megumi; in this increasingly competitive knowledge-based global economy, *education was the key*.

2. Education in the 21st Century

2.1. Fond Memories

Technology had transformed education during the 43 years of Megumi's life. When she was a schoolgirl, schools, colleges and Universities were still places where large groups of real students shared physical buildings each day, managed by real people; teachers. Megumi sat alone in her living room, sipping hot green tea, and reflecting on

her school days, remembering with great fondness her friends and the breaks between lessons when they were able to play. In Megumi's case, her parents had paid for additional private tuition, to top up her regular schoolwork, and make sure she had the best education they could afford; an advantage that helped her to keep ahead of the pack and obtain a good job and salary. As a result she had enjoyed an exceptional career, working on cutting-edge applications of intelligent educational systems.

2.2. *Seismic Changes (Mega Universities)*

Since Megumi's school days, computer based education had started to make significant inroads into teaching; starting from the use of computer aided packages for home based courses through supplementing classroom based learning to "network colleges" where online systems connected students with remote teachers; an approach initially popularised by the dramatic expansion of Asian economies in the early millennium but taken to a global extreme when the "Ivy League" universities realised that networks gave them a global reach, and allowed them to find enormous markets under the slogan "*why settle for second best when network education connects you to the best*". Around 2020, this globalisation of Universities caused major structural changes in the University system, with 3% of the Universities having over 50% of the higher education market. Some of the biggest of these new-generation online Universities came from China, where their experience of network education at the turn of the millennium meant there was in-depth experience in building the mega educational and technical infrastructures needed. In addition, their competency in Mandarin and English meant they could address the largest slice of the world's population. Of course, with such massive student numbers these new 'Mega Universities' became very wealthy and powerful. In addition to the established universities there was also a rise in new types of commercial universities that acted more like educational brokers, linking educational content providers and students by assembling personalised courses based on components from multiple sources, monitoring progress, adjusting content and verifying attainment via issuing a qualification (all but the final step being highly automated and supported by advanced AI systems). Some people regarded this as the ultimate in commoditisation of education! Whatever ones view, education had become big business in the knowledge economies of the 20's (2020 onwards), and these organisations invested heavily in the R&D to keep them ahead of the competition. Megumi smiled to herself as she recalled how this seeming fait-accomplishad been disrupted, not by other educationalist, but by technology. Megumi had good grounds to smile, for she had been part of the team developing the new 'disruptive technology' that changed the face of education in the few short years between 2040 and 2045 when the word iPod (popularised in the late 20th century by Apple as a wearable video and audio player), took on a whole new meaning!

2.3. *From iPods to ePods (background to vignettes)*

In 2025 Megumi had just finished her PhD in mixed reality, having presented her final paper at the 31st conference on Intelligent Environments IE'25. Interactive computer games were big business in the 30's (2030 onwards), having effectively merged with the world of cinema to provide "*immersive movies*", in which the audience were no longer passive observers (unless they wished to be), but could assume the role of movie characters, interacting with the story in a seemingly endless set of variations on the

storylines. As such, these new immersive movies had moved from being venues for shared group audiences (ie large public room cinemas of the early millennium) to the ultimate version of a Cineplex model; individualised environments offering highly personalised experiences via isolated high-tech-environments called '*interactive pods*', which was commonly shortened to iPod.


ADDITIVE TECHNOLOGY EPOD-4

In this increasingly competitive world, where knowledge determines success, your child deserves the very best education available and that is Addictive Technology's **EPOD-4**

Pioneering research by Benjamin S. Bloom in the 1980s (and supported by all work since) proved that students who receive one-on-one tuition learn at least an order of magnitude better than grouped students. If you want to give your child the best one-to-one education in the world, give them an Addictive Technology's **EPOD-4**

Education:

- Super-Intelligent Artificial Teachers
- Personalised one-to-one tuition (the gold standard)
- Teacher's avatar has visualisation powers that don't exist in physical space
- Available 24 hours a day, 365 days a year
- Learning environment (avatar, surroundings, lessons) can be tailored for each student
- Unwavering attention and happy disposition
- Compelling content combined with contextual delivery
- Teachers available in different cultures, ages, sexes and form



Technology

- **FREE-WILL 3 ©** - Quantum processor (upgradable)
- **MY-MIND 1.2 ©** - Evolving Persona Engine (customizable)
- **FLAME 5 ©** - EmotionWare
- **GET REAL 8.2 ©** - Mixed Reality Cocoon
- **REAL-TOUCH ©** iSkin & Haptics
- **GHOST 4.1 ©** - 3D Imaging & Audio
- **SENTINET ©** - Knowledge Engine

Addictive Technology, Zizhu Science Park, No. 880 Zi Xing Road, Minhang, Shanghai 200241, China

Figure 1. Addictive Technology advertisement describing the latest ePod-4

iPods were effectively small cocoons; something like a comfortable armchair enclosed within a sound-proof egg-like structure packed with sophisticated but largely invisible technology that included interactive 3D sensory systems (sound, vision and haptics). When *participating* in a movie (the industry had long dropped the word "watching" which describing these new immersive movies) the 3D technology aimed to make the participant feel as though they were truly part of a fictional physical world. An essential part of the technology was creating the synthesised characters, and bestowing them with sufficient natural and spontaneous behaviour so as to convince the human participant that they were real people. This was an enormous challenge to Computer Science as, from one view point, making synthetic characters that masquerade as human, was the ultimate problem to be addressed; can the human mind be created from mechanistic computing processes? In the years leading up to 2025,

computer science had made stunning progress on recreating the essentials of intelligence, building on the reasoning, planning and learning mechanisms that formed the hub of AI research in the late 20th century. However, many of the avatars produced by this type of AI created somewhat cold, machine-like, logical characters that made formidable game adversaries but lacked the spontaneity, emotion and even down-right recklessness that characterise the human condition; the qualities that make people endearing, frustrating, vulnerable, cunning and yet the most successful autonomous entity in the universe (or at least the known Universe!) and most fundamentally, personas that you want to share your life with.

Megumi thought to herself; all these 'must-have' qualities could be summed up in two short words; *free will*. She recalled how she was once inspired by an early paper by Johnson on free will [13]. Without free will, Megumi reflected, machines, robots and avatars were just deterministic machines; cold logical machines! Megumi knew everyone did not share her views, and the arguments on free-will were complex. Philosophers and computer scientists were unable to agree even what free will was, let alone if Megumi herself had free will! However, whilst free will might be important for recreating faithful replicas of people, for immersive movies much lesser degrees of fidelity were required and regular AI with slightly more spontaneous behaviour sufficed in the 20's. Megumi's PhD had addressed the issue of building more realistic avatars and, in this, she had built on work of Davies [8] who, in the early millennium, had pioneered methods to make avatar behaviour more spontaneous based on sophisticated AI techniques using a combination of genetic programming and human mimicry and people such as Egerton who had investigated the use of quantum mechanics as a means of endowing artificial brains with a more spontaneous reasoning and decision making ability [2][9][10][22]. Megumi's achievement was to perfect Egerton's quantum brains, and marry these to Davies' avatars creating immersive interactive mixed-reality movies in which most participants were unable to deduce which avatars were real-humans (wrapped in an avatar veneer), and which were entirely synthetic. Then in evaluating her work she redefined the famous "Turing Test" for human-machine equivalence, to include behaviour based criteria [20].

Following her PhD, Megumi continued research into intelligent avatars but instead of applying it to immersive cinemas and games, she became inspired by Shen's work in the early millennium online learning based natural classrooms [18] and affective learning [17], becoming obsessed with the possibility of producing virtualized versions of real teachers (virtualized intelligent synthetic teachers) that were indistinguishable from tele-conference versions of their real counterparts. By 2035, Megumi and her colleagues had reached the point where, under controlled conditions, most students were unable to distinguish between real and virtualized intelligent synthetic teachers! Of course to achieve this involved much more than giving avatars human-like behaviour, involving many computer science specialities ranging from 3D VR, multimodal HCI, (speech and gesture interaction), through affective computing and knowledge engineering to artificial intelligence, to name but some areas.

As a result of this achievement, in 2035 Megumi and her colleagues formed a spin-out company, '*Addictive Technology*', from their University which combined the immersive movie technology in the form of the iPod, with their virtualized intelligent synthetic teacher technology to make an educational pod; the '*ePod*' which, unbeknown to Megumi at the time, was set to revolutionise education and her life. Now only 8 years later advertisements for *Addictive Technology ePods* could be found everywhere. Her company was so big that it had pushed conventional Universities

aside. ePods harvested knowledge from the latest incarnation of the Internet; the UN endorsed “SentiNet” as well as from generations of earlier teaching machines (including real teachers and their books!). This step change to large-scale personalised education had brought a dramatic and fundamental change to the nature of Universities and learning, allowing a more in-situ and life long approach neatly surmised in the latest *Additive Technology* ePod-4 advertisement Megumi was just reviewing (figure1).

3. Tales from the ePod (*stories set in an ePod, as introduced above*)

3.1. Identity

John, yawned; mornings were nature's way of reminding him that there was a real world out there. He peered out from under his sheets and watched as wispy grey objects slowly materialised from the blackness, and flickering rays of light gradually added colour to the grey morning. Why did people need to sleep? In his favourite place, the ePod, day or night didn't exist but he would always become tired after as little as twelve hours in his ePod. Twelve hours in an ePod, or even sometimes longer, was not unusual as ePods were physically comfortable, like a soothing bed offering an electronic sensory feast composed of audio, video and haptic experiences that could excite the most inert mind. Although designed primarily as vehicles to deliver education, third part-vendors offered a rich choice of interactive experience extensions ranging “*immersive movies*” through to “*social interactors*”, a type of social networking but with inter-personnel haptics. ePods had strict controls to prevent ‘unauthorised activities’ but modifications were also available from backstreet vendors to make “adult versions”! John glanced around his bedroom; the new day had arrived in all its colourful splendour and it was time to get up, have some breakfast and go to school; in the mid-millennium, school amounted to climbing back into an ePod!

John couldn't wait to clamber into the ePod and meet up with his friends for a little playful fun before lessons (something's never change!). John's best friend was George who was in his ePod maths class. They had been friends since sitting next to each other (virtually speaking) when they started school at the age of 3. Like all boys, they liked adventurous games such as piloting old-fashioned aeroplanes to land on concrete runways (a crazy technology, and risky manoeuvre, that had survived until around 2030 and the discovery of atomic-levitation drives). Thus most days assumed a regular pattern for John and George, ePod lessons intermingled with ePod games. However, today was not just any day, it was special. It was John's 5th birthday and as a special treat his parents had arranged for his best friend George, to come around to play in person; a rare treat in these virtual times! John couldn't wait for the end of his lessons, no 12-hour session in the ePod today, but an interesting real-life adventure! He wondered what games they might play; maybe one of those old-fashioned football games where people physically chased after small round balls, trying to kick them into specially designated areas called goals? He was in the middle of such thoughts when his ePod announced softly “George's Levitating Vehicle has arrived”. Excitedly John raced from the ePod to the entrance of his house, ready to greet his best friend; eagerly he peered through the growing opening of the door until before his eyes alighted on a smiling face of a very beautiful young girl! “Where is George” demanded John “I'm here John, I'm here to play with you” “but you're a girl” Don't be silly, I'm George”but”

John's father shuddered as he recalled a news item a few years ago, where "Addictive Technology (the maker of the ePods) were sued by parents who claimed the ePod technology had led to their daughter taking on the persona of an avatar she had designed, which was somewhat unfortunate, as that was a talking cat ! Addictive had successfully refuted the charge by getting a physiologist to show this was a rare but naturally reoccurring manifestation of madness. He recalled, at the time, being mildly amused but now, looking at George in her pretty dress he began to wonder if twelve hours in a virtual world each day was a health risk akin to smocking in the late 20th century and would result in ePods being compelled to carry a label "*beware, ePods can damage your mental health!*"

3.2. *Dreams (aka the miracle machine)*

"Dad, what does Róisín (the ePod avatar) do at night when I'm asleep"; "haa ha, Séamus, I've told you before, without you to interact with her, she goes into a form of hibernation". "Does that mean avatars sleep like me"? "Well not exactly like you because they are not real people and don't need to sleep; now talking of sleep, go to sleep yourself". Séamus' mother, Siobhán, had died giving birth to him, and since then there had just been three of them in the family; Róisín, his dad and him. As he lay in bed, missing Róisín he wondered what she did at night; if avatars (and even parents) didn't sleep, what did they do? He decided there was only one way to resolve this, he would set an alarm for the middle of the night, get up and find out! Séamus', bedroom was very high-tech, his walls were covered with nano-computing paint to form a type of iSkin, which allowed parts of the surface to act variously as sensors (eg touch, temperature etc) or effectors (eg sound or light emitting displays). Previously, he had used an end-user programming tool to make a 'virtual appliance' in the form of an alarm clock that faked a dawning day in his room; now he simply modified that so, on triggering, his room would display the virtual view of the inside of his ePod – 3am seemed about right, so he set the alarm to that!

Joshua's alarm triggered and he awoke to a beautiful sunny morning. His mind seemed blurry, was he dreaming or was that his aunt and uncle (Ríona & Ógán) and his dad gazing down on Dingle Bay (one of his dad's favorite places in Ireland)? Joshua, Séamus, Róisín and his dad lived in Australia, a long way from Ireland, but he was not surprised to see this scene as his dad and him had often used the ePod, and virtual presence, to meet up with distant relatives, sometime spending a whole day with them in exotic places. He listened for a little while and heard his dad talking about some of the week's events. "Oh well", Séamus thought, "I might as well get back to sleep as I'm not going to learn anything new about avatars tonight, but at least I know what parents do at night"!

As he began to drift off to sleep he heard the gentle voice of another woman; he forced his tired eyes to open a fraction and glimpsed a beautiful woman with her arms around his dad; for a moment he didn't recognize her, then the memory of the picture in his dad's sleep-pod hit him; it was his mother, Siobhán. For a moment he was shocked, how could that be, she was dead, but there she was, talking about current events, tenderly stroking his dad while Ríona and Ógán looked on approvingly. He smiled, so mum is now an avatar! Suddenly, the serene moment was shattered, from behind a small boy ran into the scene and threw his arms around Séamus' mum and dad exchanging hugs and kisses; Séamus' body shuddered with a mix of surprise and dismay; who was that boy that dared to hug his parents; maybe it was Ríona's &

Ógán's son, he is about that age; he was still feeling a little upset when the boy turned towards Séamus and he felt his body go cold with shock; he stared at the boy in disbelief he was staring at himself! As he stared at himself he thought, "it seems ePods, are more than the best teachers in the world, they can reunite friends, create people that never existed, make clones of the living and even raise the dead; a miracle machine"!

3.3. *Aberrations (aka Conversations From 'The Bull')*

"Mei, are you in the ePod or the real world" said Hong in a playful voice. "Don't be silly, of course I'm in the real world, you're my real mother"! "Well you think I'm your mother but how do you know I'm not just the fabrication of a very advanced ePod". Mei, paused for a while looked sternly at her mother and said, "because there are no flaws in you; when I'm in the ePod, if you look carefully enough you sometimes see flaws such as the graphics stuttering, or losing fidelity, this never happens when I look at you"! "But what if both the ePod and I are simulations, and the ePod is deliberately simulated to look flawed"? "What if there are hierarchies of simulated worlds and the only difference between us and the avatars in the ePod are that we are just different levels of simulation"? Slightly more frustrated Mei replied, "Well, even if I don't know you are real, I know I am, because I am thinking!". Hong nodded slowly; "yes", she thought, "consciousness and self-awareness seems to be one of the more personally held, truths, but beyond that its difficult to know what is real; once you see that everything can be faked, where does it stop, can we even be sure we have bodies"? Hong continued "When ePods were first marketed nobody gave much thought to the nature of reality but now the ever-advancing ePod technology, with artificial avatars and environments that are seemingly indistinguishable from their real counterparts, has muddied the boundaries between real and simulated worlds, and has caused a dramatic rise in people needing psychiatry; to avoid insanity its important to always remember the difference between these world". Mei chuckled and nodded, "yes, don't worry mum, I remembered when I was a little girl and you used the baby-sitting application for the ePod, leaving me in the tender care of the avatar version of you, I always could differentiate between the real and artificial you; maybe some reasons were the technology limitations, maybe some was an intuition, I can't say but I always knew the difference"! "OK sweetheart, in these days of high-fidelity VR, things can be confusing but it's the same for me, I have never doubted you are real, especially your hugs, so give me a hug and lets get on with our day". As Mei watched her mother leave the room, that nagging doubt that had began with the confusion between her baby-sitting avatar version of her mother, and the other version of her mother, had returned; was Hong's movements slightly unnatural or was it she that she was sinking into madness!

3.4. *Who Made Me?*

"Pedro, you did well today, your biology ability is well ahead of the average; your ePod lessons are finished for the day, did you want to play for a while"? Isabel and Pedro had become very close since they first met, some 7 years ago. Pedro was only three years old then, but it was not unusual for children as young as 9 months to be placed in ePods which, of course, could simulate all the more traditional baby toys from the early millennium. Over the years, their type of play changed from simple baby-like matching of shapes, through 'sing-along' sessions to games such as chess or

even riding tandem cycles! ePods were also notable in that they featured “aging avatars”; avatars that seemed to age and develop with the growing child; always a little older, but the difference was always small enough to ensure a strong, friend-like bond. “What game would you like to play today Pedro”; “chess” replied Alex. Chess in the ePod was very different to the old board games of chess; in the ePod the chess characters seemed ‘alive’ and in the same 3D space as Pedro and Isabel. They didn’t play against each other, but preferred playing on the same team, against what they regarded as the collective (evil) mind of the opposing chess pieces (each piece seemed like it was alive and thinking thanks to advanced AI!). “Alex, what are you thinking about, we need to start the game”, said Isabel, looking somewhat puzzled at Pedro, who seemed to be in a particularly thoughtful frame of mind; “Isabel, I was wondering, my mother said God made my world but in today’s lesson you explained I came from the union of genetic material from my parents. That made me wonder, who made you, Isabel; I mean where did you come from and how do you grow and get so clever?”. “Well Pedro” replied Isabel in her ‘teachers voice’, “according to the ePod manual, I also come from the union genetic mater; a mechanism called ‘persona diffusion’. When Dr Egerton first conceived the idea for a conscious free-willed avatar, he had no way of building it (nor did he know exactly what was needed), so he came up with a clever idea; to create an avatar that could design slightly better avatars, which would in turn could design slightly better avatars. He figured that, if he could do this, then eventually thinking avatars like me might emerge. However, his real stroke of genius was to combine the then promising field of genetic algorithms with quantum computing in a way that evolved better and sometimes radically different versions of quantum processors. Of course he was right, because evolving quantum architectures eventually led to conscious intelligent avatars like me. Dr Egerton had been a long standing admirer of one of the quantum computing pioneers, Lov Grover (Grover’s quantum search algorithm) and named his evolving quantum processors “Grover Omniprocessor Device,” so you could say I was made by GOD (or Dr Egerton, if you prefer!). So Pedro, we are not so different, are we”?

Part A – The Link to the Authors Papers

4. Papers

I have published (with others) well over 100 papers on intelligent environments. In this section I introduce a few examples of the science-fact papers that have contributed to the science-fiction vision described above.

The story opened by describing how online-learning had developed in the 21st century to provide highly personalised learning via the introduction of a high-tech networked environment called the *ePod*. Such a system could be regarded as a refinement of current online education systems such as the Shanghai Jiao Tong University’s Network Education College, which already supports almost 20,000 online learners (who take the same examinations as their campus based counterparts) and Essex University’s MiRTLE virtual university [3] [11] [17]. To create the kind of futuristic *ePod* described in these stories requires significant advances from computer science, most significantly the development of human-like intelligence in the form of intelligent agents such as Róisín (*Dreams*) and Isabel (*Who made Me*). This has been a

long-standing goal of computer science which can be traced to the early computing pioneers such as John von Neumann [16], Alan Turing [20] and the more recent technological singularity movement [21]. At Essex we build small deterministic rule based agents, to control robots and living spaces that utilise simple reasoning planning and learning [1][5][6]. These agents are far from the realms of human-like intelligence described in the stories, being devoid of the qualities we like to believe are special to humans such as consciousness and free-will. Notions of free-will can be deeply philosophical, complex and contentious and despite numerous papers and books on the topic, the precise nature of 'self' or consciousness remains elusive [19]. That said, it is an interesting topic and a group of us have started to explore theorems from psycho-analytic studies and quantum mechanics as a means to mimic some of these human qualities [2][9][10]. In the *ePod* stories, an important aspect of the reality deception is HCI, in particular high-fidelity 3D imaging, sound and haptics. A major driver for this is the games industry, which receives financial investment similar to large block-buster movies. My contribution to this area concerns the development of mixed-reality systems (including virtual classrooms); synchronizing the real and virtual world and creating better AI and emotional response engines [3][5][6][8][11][15][17]. In *Dreams*, Séamus' room is composed of an intelligent surface (iSkin) that can be 'programmed' to act as a display or user interface. Essex has been researching nano-computing architectures [14] and end user programming (used by Séamus to create a novel alarm clock appliance) [7]. Finally, any technology that has an intimate relationship with people needs to address social attitudes and societal consequences of the technology, such as the symbiosis between Pedro and Isabel in "*Who Made Me*" which relates to earlier socio-technical research I have participated in [4] [12].

5. Concluding Discussion

In these stories the core proposition was that in the future technology would allow the development of artificial people; thinking, conscious entities (or deceptively similar) that would socialise with us, and assume the position of trusted teachers, friends and confidants. In doing so, they would disrupt many of the regular structures in society. The artificial people (avatars in our stories) would be virtually indistinguishable from people, enabling significant relationship to be formed between people and machines that at least rival those with our current pets, if not other people! An ePod could be tailored to each student, as could the virtual teacher (avatar) who could be available in different shapes, colours, sexes, cultures, ages and even in imaginative (non-human) forms. The environment could adapt to mimic any environment, blurring the natural boundaries between the real and virtual worlds. For educational applications, an intelligent avatar has the potential to pay unwavering attention to the child, never tiring, never losing their cool. It might support a person throughout all phases of their life (from education to play, from childhood to adulthood). In addition, the personalised nature, deep knowledge and superhuman capabilities of these artificial people could change the structure of well established systems, such as education; some would argue, that at this technological singularity even the dominance of people over machines would be challenged. Thus there are huge gains and huge risks in developing such technology! What would happen if machines had something akin to free-will and if their intelligence surpassed people? Can or should AI research try to take us to that point. The future is your hands.

References

- [1] M. Ball, V. Callaghan, M. Gardner, "An Adjustable Autonomy Agent for Intelligent Environments", 6th Int'l Conference on Intelligent Environments (IE'10), Kuala Lumpur, Malaysia. 19-21st July 2010
- [2] A. Bannikova, S. Egerton, V. Callaghan, B. Johnson, M. Shaukata, "Quantum Computing: Non-deterministic controllers for Artificial Intelligent Agents". 5th Workshop on Artificial Intelligence Techniques for Ambient Intelligence (AITAmI'10), Kuala Lumpur, Malaysia. 19th July 2010
- [3] V. Callaghan, L. Shen, M. Gardner, R. Shen, M. Wang, "A Mixed Reality Approach to Hybrid Learning in Mixed Culture Environments" in Handbook of Research on Hybrid Learning Models: Advanced Tools, Technologies, and Applications, Pages: 260-283 pp, IGI Global, 2010
- [4] V. Callaghan, G. Clarke, J. Chin, "Some Socio-Technical Aspects Of Intelligent Buildings and Pervasive Computing Research", Intelligent Buildings International Journal, Vol 1 No 1, Published Autumn 2008, ISSN: 1750-8975, E-ISSN: 1756-6932
- [5] V. Callaghan, Clark G, M. Colley, H. Hagra, J. Chin, F. Doctor, "Inhabited intelligent environments". In BT Technology Journal – Kluwer, Vol.22, No.3, 2004.
- [6] V. Callaghan, M. Colley, G. Clarke, H. Hagra, "A Soft-Computing based Distributed Artificial Intelligence Architecture for Intelligent Buildings", In "Studies in Fuzziness and Soft Computing", (Eds: V. Loia, S.Sessa), Springer Verlag, Volume 75, pp. 117-145, 2002.
- [7] J. Chin, V. Callaghan and G. Clarke, "Soft-appliances: A vision for user created networked appliances in digital homes", Journal of Ambient Intelligence and Smart Environments (JAISE) Volume 1, Number 1 / 2009, pp 69-75, ISSN 1876-1364, IOS Press.
- [8] M. Davies, V. Callaghan, M. Gardner, "Towards A Mixed Reality Intelligent Campus" IET International Conference on Intelligent Environments 2008, Seattle, 21-22 July 2008.
- [9] S.Egerton, V.Zamudio, V.Callaghan, V; G.Clarke, "Instability and Irrationality: Destructive and Constructive Services within Intelligent Environments", 5th International Conference on Intelligent Systems, July 19th - 21st, 2009, Barcelona, Spain
- [10] S.J.Egerton, V.Callaghan, G.Clarke "Using Multiple Personas in Service Robots to Improve Exploration Strategies When Mapping New Environments", 4th International Conference on Intelligent Environments, 21-22 July, 2008, Washington, USA
- [11] M. Gardner, A. Gánem-Gutiérrez, J. Scott, B. Horan, V Callaghan, "Immersive Education Spaces Using Open Wonderland: From Pedagogy Through To Practice", in Multi-User Virtual Environments for the Classroom: Practical Approaches to Teaching in Virtual Worlds, IGI Global, 2010
- [12] A. Holohan, J. Chin, V. Callaghan, P. Muhlau, "The Digital Home: a New Locus of Social Science Research". In The Handbook of Emergent Technologies in Social Research, Oxford University Press, 2010
- [13] B.D.Johnson, "Brain Machines: Robots, Free Will and Science Fiction Prototypes", The Ubiquitous Computing Conference, Orlando Florida, 2009
- [14] A.King, V.Callaghan, G.Clarke "Problems Developing an Amorphous Computer as an Intelligent Skin for Pervasive Computing", Proceedings of the 2005 IEE International Workshop on Intelligent Environments, Colchester (IE05), Colchester, UK, 28-29th June 2005
- [15] E. Leon, G. Clarke, V. Callaghan, F. Doctor, "Affect-aware behaviour modelling and control inside an Intelligent Environment". In Pervasive and Mobile Computing, Elsevier B.V, 2010
- [16] J. von-Neumann, *The Computer and the Brain* (New Haven: Yale UP, 1954).
- [17] L.Shen, V.Callaghan, R.M.Shen "Affective e-Learning in Residential and Pervasive Computing Environments", Journal of Information Systems Frontiers (special issue on "Adoption and Use of Information & Communication Technologies (ICT) in the Residential/Household Context"), Published in Information Systems Frontiers, Volume 10, Issue 4, pp 461-472, ISSN:1387-3326, Kluwer Academic Publishers Hingham, MA, USA, September 2008
- [18] R.M.Shen, M.J.Wang, W.P.Gao, D.Novak, L.Tang, "Mobile Learning in a large blended computer science classroom: System function, pedagogies, and their impact on learning", IEEE Transactions on Education. 2009
- [19] A.Sloman "How To Dispose Of The Free Will Issue", *AISB Quarterly*, Winter 1992, Issue 82, pp.31-2
- [20] A. M. Turing "Computing machinery and intelligence", *MIND* (A Quarterly Review Of Psychology And Philosophy), VOL. LIX. No.236, October, 1950.
- [21] V.Ving "The Coming Technological Singularity: How to Survive in the Post-Human Era", Winter 1993 issue of Whole Earth Review
- [22] P.Zizzi, Journal of Physics Conf. Ser., 67,. 012045. (2008). "I, Quantum Robot: Quantum Mind Control on a Quantum Computer