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Preface

Introduction for the Journal of Information Sciences special issue on serious games

Over the last 15 years, there has been an explosion of interest in using computer games for purposes other than entertainment. This is in part due to the expansion of new genres of casual games, online games and mobile games that have collectively widened gamer communities all over the world. In parallel with this growth of new *genres* of games, the success of games to motivate and engage latterly became a subject of study and science leading to the justification for their use in *non-entertainment* as well as entertainment contexts. This emergence of so-called 'serious games' has produced in parallel the start of a new academic field, nominated here as: *Game Science*.

Serious games broadly are described as games for non-entertainment purposes, and often utilise educational and behavioural change as key drivers for usage. But while the pockets of development have been spurred by 'first generation' serious games titles, such as *America's Army*, *Re:Mission*, *Triage Trainer*, *Levee Patroller* and *River City*, criticism has been aimed at the field for not being able to organise itself leading to fragmentation and a putative 'disconnect' between disciplines and between USA, European and other international research and development centres. To overcome this, leading lights in the field have strived to bring the communities together through cross-cutting conferences such as IEEE VS-GAMES (since 2009), European Conference on Game-Based Learning (ECGBL; since 2007), and the Games, Learning and Society Conference (GLS; since 2004). Importantly, the European Commission have invested a large tranche of funding into establishing the Framework 7 GALA network of excellence in serious games. In the USA, both federal and non-profit organizations have also invested large amounts of funding into research and development which in some cases includes establishing bridges between isolated researchers. These initiatives, and others, have started the ongoing process of building bridges between the international research and development communities and have started to defragment research across the world. However, more work is needed to introduce shared development models, processes and tools and to facilitate sharing best research practices. The issue of replication is also a concern here and the need to share resources and to cross-validate studies has driven the Serious Games Institute (www.seriousgames.org.uk) affiliate program which now has partner institutions in four continents.

With the first significant number of PhD students emerging from their studies, the growth of the scientific field of game science is set to continue strongly, with lessons learnt from 'first generation' serious games being used to inform the better design and efficacy of 'second generation' serious games. But unless the arguments can be made powerfully to policy makers and funding agencies the development of the field may be stalled or, worse still, retreat back into national contexts, losing some of the power of reach to larger global audiences. For this reason, this special issue provides a rallying call to subject matter experts, researchers, game designers and developers to find and explore new opportunities for supporting collaborative work especially transcending national boundaries and with close industrial involvement. While we recognise that this is difficult, we are convinced that by lobbying with national organizations we can put games on the agenda, not least for its capabilities for changing behaviour and raising awareness of important social and health, education and political issues of concern to international audiences.

But we should not underestimate the challenges for the new field and sector. On the research side of things, difficulties include access to literature which is scattered across many disciplinary areas. For developers, design and development cycles are substantially different from commercial entertainment games companies where teams work on single large titles rather than on many small demonstrators at once. For policy makers, the issue of cross-generational boundaries is challenging and for educationalists, a general resistance to change and risk aversion of the sector is notable. As a result of the complex and interconnected nature of the field, researchers can feel marginalised and unable to always gain the kudos and credibility required for making more substantial advances as part of the wider international community of designers, developers and researchers.

Another challenge and opportunity we face is the applicability of our genre for a wide range of sectors including business, creative arts, manufacturing, health and education. While this is a positive aspect of working with games as tools, it can also

be daunting in terms of the broad nature of inter-sector engagement. For most academics, we are not always well prepared to deal with so many different sectors and the need to adapt to different requirements and to interact on a business level is a skill acquired only after some time and with some successes and failures. We need to find a way to share these experiences and to try to advance the field through targeted professional and masters level training and education. Opportunities for interacting with business at the earliest stages seem a sensible strategy even for the youngest students.

The serious games researcher then needs to have many different hard and soft skills: you have to be able to engage with large datasets, develop your own methods and approaches and have an ability to interact with different sectors and disciplinary areas. Having an entrepreneurial sensibility is also a handy skill to have as funding sources are not always in the academic comfort zone and opportunities to spin out and start up companies seems commonplace. Therefore we feel that this special issue alongside other collaborative activities are essential for bringing the community together and supporting individual researchers. Of course there will not always be agreement on the best ways to achieve this, but we are fortunate that some far-sighted funding agencies such as the US National Science Foundation, UK Technology Strategy Board and European Commission have identified the power of games not only to engage and motivate but also to solve world-scale problems and make significant and important behavioural and social changes to improve our lives, work and study.

One of the main issues that has prevented better and closer interworking between these established communities of researchers and game designers is lack of knowledge of one another and another main issue is a lack of any dedicated funding opportunities. This special issue attempts to address the first of these issues, but we ask colleagues to work together to try to entice policy makers and funding bodies who have yet to fund game-based learning approaches to start to get involved as part of a wider internationalization agenda and as part of addressing the potential of games as a method for teaching and learning, through paying for leading edge game solutions for all ages and for supporting leading research into the efficacy and best design models for serious games.

While we acknowledge that games movements such as Games for Health and Games for Change have managed to ignite some public interest in games, it is 'gamification' and the use of games widely in business contexts that seems to be having a significant impact most recently. While we applaud all these movements, we sound a note of caution regarding the tendency to separate different communities out too much, partly as this may dilute the advances we make on the science side of game deployment and design. We have spent a long time trying to get the communities to talk to one another, so it is vital that we maintain good communications, however disparate they may seem or may become.

To bring the communities together, this issue reveals some of the diversity of the field and draws together seven articles that cover elementary and secondary education, pre-service teacher education, business simulation and social skills teaching. While many of the articles are concerned with showing the validity of using game play to support education and training, many of the studies reveal interesting insights in the diversity of skills and knowledge that games can be used to teach. The prevalence of papers concerned with science education with a focus upon Science, Technology, Engineering and Mathematics (STEM) education shows the significant interest in using games for supporting this area of education and the wider governmental initiatives with sustaining and developing new methods of engagement of students into these fields.

In addition to illustrating games that vary on content and audience, these articles display a diversity of definitions as to what a serious game is. The field has yet to decide whether a serious game should be defined narrowly or not. Currently, games can vary on a number of dimensions: number of users, source, and immersiveness, for example. Further, while simulations are not games per se, a set of 'simulation games' has started to arise. These dimensions are represented in the serious games presented in this issue. Annetta and colleagues, Nelson and colleagues, and Lester and colleagues utilise a single-user 3D immersive game. Similarly, Castellar and colleagues investigated a single-user 3D game, but theirs was a commercial game. Bernardini and colleagues created a 2D environment in which a 3D computer agent resides and interacts with single users. Ranchhod and colleagues present a simulation game, played by teams. While Frezzo and colleagues call their environment a 'micro-world,' it is described as a multi-user simulation game as well. As you read these articles, think about not only how one should define a serious game, but whether specific dimensions of a game might play a role for a specific goal or group of users. Perhaps the question should not be how to define a serious game but rather what is the impact of various aspects, for whom and when in order to maximise success.

The first article by Lester and colleagues explores the efficacy of the education game called Crystal Island, which is used to teach upper level elementary science. The paper reveals significant gains in learning for children both in science content and in decision making, revealing strengths for game based approaches in knowledge and skills areas in parallel. Another interesting insight from this paper is that gender gains were equal, supporting some earlier work from one of the editors, which showed that serious games have equal appeal to both girls and boys [2]. This is a finding that warrants further consideration in future studies to identify design elements that foster engagement for both girls and boys.

While Lester and colleagues used a proprietary game with their study, Castellar and colleagues considered how arithmetic skills can be taught through game play by using a commercial off-the-shelf (COTS) game with 88 elementary students. The study is important as very few studies have so far demonstrated any effectiveness of using commercial games for education and training, while most proprietary games have consistently shown efficacy. Interestingly, this study showed gains in affective and cognitive learning in the students, a finding that reopens the need for more studies with COTS games.

Staying with the interest area of STEM teaching, Nelson and his colleagues investigated the role of visual signalling in a virtual world educational assessment around science inquiry and content. Working with 2,000 7th grade students, Nelson and colleagues investigate the hypothesis that students can be more readily tested for higher-level cognition and comprehension of inquiry-based science through more visually focused immersive environments. The study reveals positive find-

ings in favour of this hypothesis that testing in more visual environments significantly reduces the students' perception of cognitive load and thereby increases the efficiency of this form of assessment. The findings offer a significant advance in our understanding of game-based assessment and offer new paths for future research.

Bernadini and colleagues reveal interesting insights into using game approaches for teaching social skills to children with autism in their study. Here, controlled interaction between autism spectrum children and a playful virtual agent focus upon developing social skills incrementally. While this study reveals very early work in the field, there is promise for ongoing studies based upon a cognitive concept of social partnering for learning which could be adapted for other learners and has particular promise for younger learners at particular developmental stages. The work builds upon a small but growing area in the scientific field of avatar science with games and has implications in a range of related disciplinary areas of psychology, education science and computer science.

Annetta and colleagues continue the theme of science education with their study, which focuses upon pre-service science teachers. The game developed was based upon a module, which focused upon laboratory safety and preparation for secondary school science study. The study revealed positive gains for teachers engaging with the study programme and indicates that all the groups of teachers liked the mode of learning. Serious games studies have in general demonstrated that games are well liked by different user groups and this study confirms this finding.

Ranchhod and colleagues take our focus away from school children and education towards higher education and teaching. This team is interested not only in proving if games are effective but stepping further and understanding more about *why* they are effective. The study focuses upon a marketing teaching game and upon how experiential learning is promoted through it. They put forward a new educational value model for testing this that can be used in different contexts, and validate it using structural equation modelling with a group of 305 students. The study provides critically important tools for assisting other researchers in the field through the study which sets out four types of educational values as: 'experience generation, conceptual understanding, skills development and affective evaluation'. The study creates a useful validation whereby *experience generation* is demonstrated to have a strong impact on *conceptual understanding*, and showing how both of them 'have medium to high direct impacts on skills development'. This model will certainly be used to inform future studies and may be used to further validate other considerations of learning with games for example learner retention and increased memorization [1].

The final paper by Frezzo and colleagues brings together a number of the strengths of game-based and simulation-based learning by considering a 'micro world' for teaching computer networking to higher education students with a strong focus upon preparing students for entering the professional workplace. The game tests for knowledge, skills and social learning, providing useful insights into game design and the role of simulation for supporting students into workplace. Much focus in the field of simulation has already proven the efficacy of these approaches for professional training for medics and lawyers for example, but this work focuses upon real time feedback and assessment. The study uses a significant sample size of 12,000 students playing ASPIRE and again a focus upon cognitive processes was highlighted in the study design. While the study reveals the tip of the iceberg in terms of what can be achieved through learning analytics connected to games, the richness of the large data set will reveal further insights and has the capability to evolve into a useful and timely tool for assessment of complex cognitive learning processes.

The journal reveals the richness of the international field in terms of the breadth and scope of the studies underway, we hope that the issue will encourage researchers from all over the world to cross-reference and integrate each other's study designs and methods to avoid silos and disconnects in the literature base. While we acknowledge the problems with working between continents we hope that this issue reveals the value of bringing our work together to benefit incremental improvements in the way we learn and teach.

References

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