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Examples of work

1. Virtual Reality

a. Seaweed Heroes
I have been working in an entrepreneurial effort, with an artist friend, to develop Seaweed Heroes (http://www.seaweedheroes.com); a unique multiplayer virtual reality game, using Unity 3D, C# and Vive Head Mounted Display (HMD) and controllers. We currently have single and multiplayer prototypes (see the trailer at https://www.youtube.com/watch?v=dPktpu4SI8w).

b. Steampunk Sky Pirates (https://www.youtube.com/watch?v=7w2-YAg21h4)
This is a virtual reality game prototype was developed in 2016 using Unreal Engine 4, Oculus Rift DK2 and Leap motion. Leap Motion is used for hand tracking and player input for rocket-propelled flight. Flight behaviours for enemies and allies (based on Craig Reynolds' Flocking behaviours) were developed in C++ exposing functionality to Blueprints.

c. Monster Maze (https://www.youtube.com/watch?v=1BjB_7e_fas)
Monster Maze is a virtual reality game prototype I developed in 2016 using Unreal Engine 4, Oculus Rift DK2 and Leap motion. Leap Motion hand tracking is used for combat and player movement. The mazes are procedurally generated using C++ and exposed for Blueprint implementation.

2. Gamification

During my postdoctoral research at the Department of Computer Science, University of Cape Town, I collaborated with academic staff from 2013 to 2016 on the iterative development, implementation and evaluation of the gamification of the 'Computer Game Development' course offered to 2nd-year students. The gamification aims to support course objectives by improving students' review of course material, increasing meaningful class participation, fostering problem-solving skills, increasing lecture attendance and encouraging creativity in practical assignments. This was achieved by enhancing the existing course using various gaming features (narrative, characters, puzzles, quizzes, leader board and rewards) towards learning objectives, motivational affordances, engagement and behaviour change. The gamification integrates course content, class activities and lectures with the gamification activities through the University of Cape Town's Sakai learning management system.

The evaluation of the gamification considers both quantitative and qualitative measures analysing various data sources: lecture attendance, online gamification activities and scores, online chat discussions, course evaluations, gamified and non-gamified course grades, and interviews. Activity theory provides a valuable framework to represent and communicate the complex the cultural-historical processes that constitute gamification activity. Our research also shows that effective gamification requires the gamification to penetrate and transform the existing course activities and not simply be a superficial layer added on top.

We found that the gamification had a positive impact on student engagement with the course. It increased lecture attendance, class participation and student enjoyment. Student engagement in learning activities is a key indicator of high-quality learning. Observations suggest that student agency is crucial for a positive emotional response and necessary for students to buy in and realize the learning activity. Digital media can provide such opportunities for learning. However,

digital media is assumed to be inherently motivational. This assumption is not empirically supported. I presented our findings at the 49th Hawaii International Conference on System Sciences in January 2016.

3. Artificial Intelligence and Machine Learning Serious Games

a) A* Pathfinder Serious Game

We found that students often understood the A* pathfinding algorithm conceptually. However, in practice, the recursive steps of the algorithm were not performed systematically. I developed the A* Pathfinder serious game to provide students with a fun drill-and-practice exercise of the algorithm.

Storytelling is used to motivate and direct students toward the execution of the algorithm. In the game story, Dr Gerasimov (a scientist that found himself as a head in a jar after a near-fatal accident) requires the player to find mechanical components in the maze-like laboratories to build a mechanical body for him. The A* Pathfinder Mechanism (a compass-like user interface element) scaffolds the learning of the A* Pathfinding algorithm. It is presented in the game story as an ingenious machine that calculates a safe (shortest) path through the laboratories and their traps. As levels progress the Pathfinder malfunctions, requiring students to manually set values. Through this, the scaffolding of the learning is gradually removed. When students make mistakes, they set off traps that deplete player health serum and score. Dr Gerasimov provides feedback to the player. This immediate feedback is highly valued by students and facilitates their mastery of the algorithm.

Students report that they found it easier to visualize the execution of the A* algorithm as it was stepped through using the dynamic and interactive serious game. They found the visual aspects and animations of the game appealing. Students rated the immediate feedback and the Pathfinder Mechanism highly valuable when considering what contributed to their learning.

b) Enforcer Gauntlet Nero-evolution Tournament

Students find Artificial intelligence challenging. They often consider it as difficult ‘black box’ technologies and mathematical formalisms. I developed the Neuro-evolution Tournament for the 3rd year ‘Machine Learning’ course in consultation with the Artificial Intelligence (AI) lecturer. The system scaffolds the complex algorithms of Q-Learning and NeuroEvolution of Augmenting Topologies (NEAT) through an interface with sliders that players can use to configure the fitness functions used to train agents.

Storytelling and competition are used to motivate and engage students in the training of agents. Set in a cyberpunk world students are recruited for the ENFORCER GAUNTLET TOURNAMENT PROGRAM. "The Corporation" utilizes the tournament to identify the best and brightest "Agent Brain" trainers of robot mechs.
(https://www.youtube.com/watch?v=KEkP3RcepQk)

Players compete for rank and prizes through personal assessments and the performance of their teams of agents. The tournament is organized around 3 missions and allows for the pre- and post-test evaluation of learning. The missions present players with 3 maze solving problems of varying complexity. Students reported developing a better understanding of the relationship between the fitness function and the agents’ behaviour. They also learned that agents’ behaviours are best tuned over many iterations.

4. Virtual Environments

I completed my PhD at the Department of Computer Science, University of Cape Town in 2009. I attained a competitive scholarship from the Collaborative African Virtual Environment Systems (CAVES) initiative to conduct this research. CAVES was a joint venture between the University of Cape Town (UCT), government and industry. It included UCT's departments of Computer Science and the Centre for Film and Media Studies, National Research Foundation, Council for Scientific and Industrial Research, Contemporary African Music & Arts Archive, Visual Information Systems and Video Labs. The main objective was to overcome the problems with creating Virtual Environment (VE) systems for the South African context.

The goals of CAVES were to construct a methodology for developing multicultural VEs, tools for supporting the authoring of VEs and low-cost platforms that would exploit anticipated advances in technology. I participated in the Collaborative Visual Computing (CVC) group. The methodologies and tools we developed aimed to enable artists and media students without programming experience to develop and prototype VEs. I collaborated with artists, media students and programmers to make sure that the tools and methodologies we developed met user and technical requirements.

My PhD research develops a meta-theoretical framework for conceptualising learning in Virtual Reality. The research contributes to a novel dialectical methodology to design and evaluate learning activities in virtual worlds. This is done by expanding activity theory for group praxis.

Research outcomes:

- Beirowsky, C., & Vermeulen, H. (2004). Experiences with virtual reality accessibility in an African context. In Workshop Proceedings of the IEEE VR 2004 Conference, Chicago.
- Vermeulen, H. (2009). Learning in a virtual world: Expanding activity theory for the design and evaluation of group praxis. PhD Dissertation, Department of Computer Science, University of Cape Town.
- Meta-theoretical framework for conceptualising learning in Virtual Reality
- Methodology developed to design and evaluate learning activities in virtual worlds
- Evaluation of Activity Theory as constructivist pedagogy and framework
- Expansion of Activity Theory to meet challenges identified in practice
- Unreal 2004 Collaborative Storyboarding Previsualization Virtual Environment
- Unreal 2 Collaborative Virtual Film Production Virtual Environment