MINECRAFT AND GRADE 6 SCIENCE

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Conducted with two classes of Grade 6 students during consecutive 50 minute sessions, in total 42 participants were involved with my project (24 boys and 18 girls). A 1:1 iPad program has been implemented at this large, South Eastern suburbs government school and all students with their own devices are able to access the school server, enabling students to join each other's worlds to work collaboratively on the challenge. Additionally, the classroom was equipped with an Apple TV which allowed designated students to Air Play the construction of their Minecraft world as well as their resulting structures. At the conclusion of the session, students were encouraged to complete the accompanying survey accessible via QR code.

Hypothesis/Problem to solve

How can Minecraft be used with Grade 6 students to effectively teach scientific concepts and facilitate student engagement?

Despite many experts in the field of education advocating that "an education in STEM subjects is the ticket to a decent-wage paying career in the economy of the 21st century" Morrison & Bartett, 2009, p. 28(), Cooper, Kenny and Fraser 2012() establish that at a primary school level, science teaching has the second lowest allocation of time in the Australian school curriculum. During the infrequent occasions when science is being taught to primary students, a lack of pedagogical knowledge often results in teachers "following the text book very closely" and the delivery of classes which are "teacher-centred and didactic" Ma, 2004, p. 183(). Supporting a pedagogical shift from a teacher-centred approach, the National Science Resources Center (1997) emphasises that science teaching should provide students "opportunities to ask questions, to plan and conduct investigations, to use appropriate tools, to think critically and logically, to construct and analyse alternative explanations and to communicate" p. 69(). However, rather than facilitating student learning through hands on experiences and inquiry learning, Nowicki, Sullivan-Watts, Shim, Young, and Pockalny (2013) argue that many inexperienced teachers continue to "spend more time 'telling' students scientific facts rather than guiding them to construct knowledge" (p. 1137).

While knowledge of contextual scientific terms is important to facilitate comprehension, Fitzgerald (2013, p. xxi) argues that teachers "delivering content as a series of indisputable facts for students to memorise and regurgitate" is incongruous with alternative "rich approaches" for instruction. Anderson and Moeed (2013) outline that disengagement from science amongst upper primary students is often the result of negative student perception. Student motivation and engagement are dramatically reduced as a result of negative connotations regarding the topic (such as a lack of relevance and inadequate intellectual challenge). This disengagement resonates with arguments presented by leading gaming advocate Jane McGonigal (2011, p. 4) who contends that more than any other generation, today's "born digital" students are suffering in traditional classroom environments where "low motivation and low-challenge" persist for the majority of students. Furthermore, Prensky (2001, as cited in Wilkes, 2006) suggests that more appealing approaches to instruction rather than re-designed content is the key to student participation.

Many experts in the field of education are now embracing the idea that computer games may in fact provide teachers with an unrivalled instructional tool by which to engage and motivate their students. As Wilkes (2006) proffers, the interactive nature of digital games enables students to "create learning environments where they learn by doing, they receive immediate feedback, continually build new knowledge and enhance their level of understanding" (p. 43). Virtual worlds provide opportunities for students to practice fundamental scientific skills such as conducting experiments to test hypothesise, making observations and collaborating with their peers to solve problems and debate assumptions. This, as Perrotta, Featherstone, Aston, and Houghton (2013) discuss, is the inherent appeal of utilizing games for learning – students are afforded the opportunities to interact with ideas or topics through simulations that they may not be able to experience in the 'real world'. According to McGonigal (2011) tackling epic challenges and failing without fear are also pivotal benefits to virtual learning environments.

My hypothesis therefore evolved essentially from these two main strands - a lack of science content in primary classroom and enhancing student engagement. Having previously worked with this particular student cohort two years prior as an integration aide, I was aware of their existing scientific knowledge. Possessing established relationships with the majority of the students in these classes also provided me with the confidence to experiment with my novel idea. As Beutel (2015) articulately explains there is a discernible distinction between "being an expert user of ICT and being a teacher who makes creative and effective use of ICT" (p. 193). My knowledge of Minecraft would undoubtedly situate me in Beutel's second category however I was confident in not only my ability to successfully facilitate the activity but as Wilkes (2006, p. 43) discusses, the notion that the students possess far more "technological sophistication and experience" than me.

Theoretical framework

Although research shows that game based learning has the capacity to considerably impact the cognitive abilities of students, Robinson (2014) reasons that while it is important for schools to embrace digital technologies within their classrooms, pedagogical approaches must be adapted to meet the learning needs of students. By failing to consider the learning styles of modern children and the pedagogical implications of these preferences, digital games become "merely replications for the type of teaching already occurring in non-digital classrooms" Robinson, 2014, (p. 33). As "today's students are no longer the people our education system was designed to teach" (Prensky, 2001 as cited in Wilkes, 2006, p.42) a more hands on, student-centred approach to learning is now popular within the education field.

Cognisant of theories developed by influential figures such as Piaget, Dewey and Vygotsky, constructivist learning advocates that students do not simply 'absorb' what they are taught. Instead, learners 'construct' their understanding through the interplay of prior knowledge and new experiences. Embracing the concept of lifelong learning, theorists profess that the most "meaningful learning occurs when people actively engage with making sense of their world" Churchill et al., 2013, (p. 213). This pedagogical approach places students at the centre of the learning process. No longer simply passive receptors of information from teachers long regarded as the "sole purveyors of knowledge" Waniewski, 2012, (p. 1), constructivist learners take responsibility for their own learning, co-constructing their knowledge in collaboration with their teachers and peers.

In her article 'Boys, ICT & Engagement', Wilkes (2006) suggests that introducing digital technologies into the classroom requires teachers to be unperturbed by the fact that the majority of their students will bring to the classroom considerable "technological sophistication and experience" (p.43). This idea resonated with my approach to the Minecraft sessions – I openly acknowledged with the students that they were the 'experts' with this technology, I was merely posing a challenge for them to investigate within a virtual world. By empowering the students to become "agents of their own learning" Gerber, Schamroth Abrams, Onwuegbuzie, & Benge, 2014, (p. 28), they were able to demonstrate their technological expertise together with higher order thinking skills such as problem solving and creativity. A noteworthy theme throughout my readings into effective science teaching emphasised that simple, practicable experiments which enable students to (independent of teacher intervention) "solve problems with their peers, learn from their classmates and repeat experiments to check results" Fogleman, McNeill, & Krajcik, 2011, (p. 152) increase student achievement. This was essentially the appeal of the Minecraft experiment – it represented simple, hands on challenge for the students that they could complete in collaboration with their peers, devoid of significant intervention from the teacher. Conversely, Gerber et al. (2014, p. 30) demonstrate that "heavily scripted and uni-dimensional tasks" restrict "socially constructed meaning making". Student-centred learning necessitates a flexible pedagogical approach which allows for student "ideation and iteration" Gerber et al., 2014, (p. 30) both independently and in collaboration with peers.

Inquiry learning embraces constructivist practices and encourages students to be hands on, to participate in student led experiments and to liaise with their peers. The National Science Resources Center (1997) emphasises that conceptual understandings are enhanced when students are afforded regular opportunities to participate in 'hands on' experiences. Gee agrees, (Thorn, 2013) reasoning that "learning though doing" is not only an essential component of the learning process, but is also an inherent characteristic of gaming.

Despite the growing evidence indicating that students who participate in gaming for learning programs are "more engaged in curriculum content and demonstrate deeper understanding of concepts" Krotoski, 2010, (p. 695), controversy still surrounds the effectiveness of games to transfer meaningful knowledge. Gerber et al. (2014) examine the argument that rather than the digital technology itself, it is in fact socially constructed learning that facilitates knowledge acquisition for students. The authors elaborate further upon this contention by stating that although games which have been designed specifically for educational purposes can benefit students, off-the-shelf games regularly lack specific links to the curriculum and are often limited due to inaccurate content. Simoes, Diaz Redondo, and Fernandez Vilas (2012) allege that in these circumstances, "learning only occurs as a side effect" (p. 2).

Gaming for learning campaigner, James Paul Gee Thorn, 2013() however speculates that "games, not school, are teaching students to think". Digital gaming enables students to apply the facts and the information they have learnt to "well designed experiences in problem solving" Gee, 2013, (p. 18). Morrison and Bartett (2009, p. 28) concur with the relevance of Gee's statements outlining that the ability to solve "problems by applying knowledge to design solutions" will be a requisite skill for an increasingly STEM orientated workforce. Although digital technologies present teachers with an engaging and effective instructional tool, the successful implementation of a gaming for learning program is ultimately determined by its pedagogical approach. Despite their enthusiasm for gaming, researchers such as Gee and Wilkes, continue to recommend that teachers still need to focus on desired learning outcomes before considering how gaming can be implemented to facilitate learning.

Results

Link to Australian Curriculum: Grade 6 – Science Inquiry Skills

ACSIS232 – Questioning and Predicting:

- *With guidance, pose questions to clarify practical problems or inform a scientific investigation, and predict what the findings of an investigation might be*
- *applying experience from previous investigations to predict the outcomes of investigations in new contexts (ACARA, 2014)*

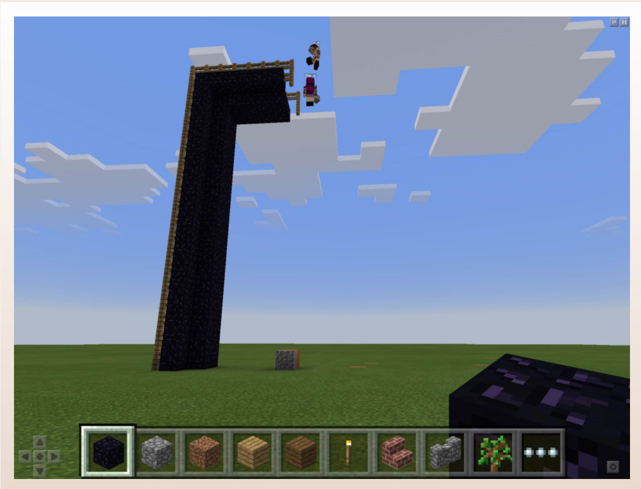
What did the students do?

Hearing a rumour that we would be using Minecraft in the classroom definitely sparked the curiosity of the Grade 6 students! They were extremely eager to find out what we were doing and to make a start on the challenge. Cognisant of the students' prior knowledge, I invited students to share their knowledge regarding who Sir Isaac Newton was and what he discovered about gravitational force. Following a brief tuning in exercise where a bag of sand and a feather were dropped simultaneously, I asked students to then consider the properties of gravity in the virtual world of Minecraft. By applying their existing knowledge of gravity to a new context, the learning intention of this activity was to investigate whether gravity exists in the Minecraft world and whether it is accurately represented.

Before the students began, we also established that the blocks in Minecraft are representative of one cubic metre. I proposed to the students that, in the real world, a cubic metre of sand is roughly the equivalent weight of a large brown bear. Students then predicted that blocks of sand and gravel should fall considerably faster than snowballs in their Minecraft gravity experiments.

Dot point instructions were written on the board for the students as I felt that in their haste to begin the challenge, some students failed to carefully listen to the guidelines (Appendix PDF). Although the majority of students had their own iPads during the sessions, some students did not have Minecraft installed on their devices. To facilitate involvement, these students were paired with classmates able to access the game.

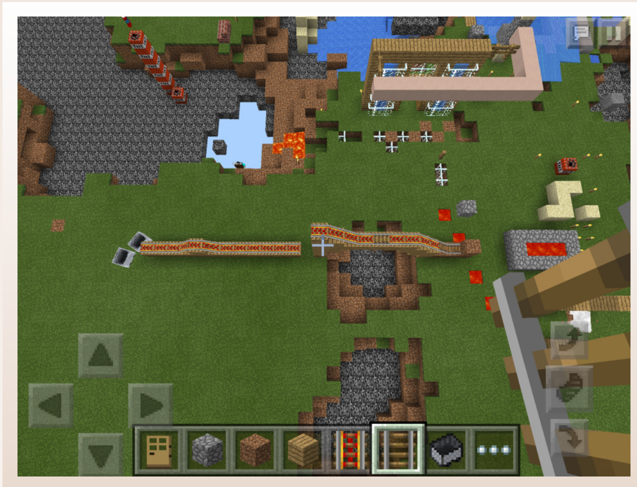
The first class of students made an enthusiastic start to the activity. They diligently set about co-operatively building their structures and discussing how to solve the problems associated with releasing the objects to test their fall. One well-organised group quickly discovered they could fly above their target.



The 'flying' group members then dropped their objects while other members observed from the ground and timed the falling items. They conscientiously tested and re-tested their experiment and recorded their data.

Another group constructed a tower to house their blocks of gravel and sand. They then smashed the obstructing blocks, allowing the test blocks to fall to the ground. Again, a third member of the team observed the results from a vantage point below. Attempting to simultaneously release their objects was challenging for the students, necessitating repeat experiments to achieve accurate results. Additionally, some groups experienced technical difficulties in relation to joining worlds with other group members. These experiences were not necessarily negative for the students involved and may in fact illustrate meaningful engagement with the activity. Phillips, Horstman, Vye, and Bransford (2014) speculate that emotional experiences such as frustration are often genuine catalysts for future learning. Rather than simply evaluating engagement in relation to compliant student behaviour, Phillips et al. (2014, p. 551) claim that the "persistent re-engagement" demonstrated by the students (staying focused, displaying a commitment to completing the task, opting for challenging tasks) is equally critical to the learning process.

Interestingly, the second Grade 6 class participated in the activity in a markedly different way. Some students, rather than building new structures, adapted creations they had constructed previously in their own Minecraft worlds. One group of students diverted slightly off task and began testing the trajectory of cannons by firing snowballs and gravel blocks. Another student carefully modified a rollercoaster



which launched items towards a target. He then measured which items travelled the furthest distance – ultimately experimenting with perpetual motion rather than gravity but an interesting aside nonetheless!

However, a considerable portion of the second class engaged in off-task behaviour during the session. Often resulting from difficulties with joining worlds with other group members, these students continued to play Minecraft but independently delved into their own Minecraft worlds. Sabotage also became an issue among the students – rogue team members were destroying their own team's creations while some students infiltrated the worlds of other groups primarily to sabotage their structures.

What did the students discover about gravity in the Minecraft world?

Through their experiments, the students discovered that although gravity does exist in the virtual Minecraft world, it is a far from accurate representation. Blocks of sand, gravel and even snowballs all fall at relatively the same speed when in fact, the variations in their mass should result in significant differences.

Student feedback

34 of the Grade 6 participants responded to the accompanying 10 questions survey. Accessible via QR code, the survey provided an insight into student gaming behaviour as well as their opinions regarding the Minecraft activity and gaming for learning.

The most striking result was an overwhelming 75% of students indicated that they would like gaming for learning to be included more regularly in their classrooms. Student's commented:

- *"I could show my work in a fun way"*
- *"I wish we could use gaming for school more!!"*
- *"Gaming can be viable although a child's learning can be somewhat distracting"*
- *"I think that it will get kids involved in learning"*

These comments indicated that students found the activity to be engaging and that they also appreciated the opportunity to demonstrate their creativity within an alternative medium. When asked to identify their favourite aspect of the activity, 40% of the students indicated that using games for learning was the most appealing component. Interestingly, other secondary aspects such as collaborating with friends, testing scientific concepts in a virtual world and participating in a challenging task all received an equal share of the student vote (13%).

Blyberg (2015, as cited in Lorence, 2015, p.28) claims that "the longevity of Minecraft's popularity is unprecedented". While this may definitely be the case, the off task behaviour exhibited by some members of the second group made me re-consider the appeal of Minecraft to this particular age group. The resulting survey results to some extent confirmed this concern, indicating that the majority of the students (67%) only occasionally still played Minecraft at home.

Despite the problems with students in the second group sabotaging each-others work, the replies to the survey showed that 63% of the students felt they had experienced no problems during the activity. Although a number of students commented on the sabotage obstructions and issues with group dynamics, most students were pleased with the structures they were able to construct.

- *"Our platform got set on fire so we rebuilt"*
- *"One person was too controlling"*
- *"We started off slow but when we got further in we were more efficient"*

Only 6% of students indicated that they felt the lesson was not engaging. A small number of students in each group did not have access to Minecraft via their iPads and despite my efforts to partner these students with others who could access the game, not all teams equally shared resources. Students excluded from directly participating in the game may therefore have responded negatively in relation to engagement with the activity. 48% of the students however, responded extremely positively on the engagement scale with comments such as:

- *"It was fun, I recommend to do it again sometime this year"*
- *"It was great, I liked it because it was fun and I actually wanted to do it!"*
- *"Little more time for structures and experiment but the rest was enjoyable"*

Encouragingly in relation to the curriculum guidelines for the session, 45% of the students surveyed believed the activity had enabled them to apply their scientific knowledge in a new context.

Is Minecraft an effectively designed instructional tool?

In relation to teaching science, the "pedagogical design capacity" (Brown & Edelson, 2001 as cited in Fogleman, 2011, p.151) of computer games such as Minecraft ensures that materials can be readily adapted to meet the learning needs of students while still preserving the original intent of the game itself. Lorence (2015) concurs stating that "the simple interface provides students in the classroom with endless possibilities to demonstrate creativity, think critically, communicate, collaborate and solve problems" (p.27). Additionally, Bilton (2013) explains that games like Minecraft encourage students to participate in 'parallel play' where learners are "engrossed in their game but are still connected through a server or are sharing the same screen" (p.9). These elements are extremely appealing when considering implementing Minecraft into my classroom. By researching how other teachers are using Minecraft for educational purposes, I found a plethora of information regarding science, maths, literacy, history and language instruction. Many teachers have not only created their own worlds for students to explore (including accurate representations of The Forbidden City or fantasy worlds where students can examine the impact of sustainable practices) but many schools have adopted Minecraft Edu - a relatively new educational version of the web based game. The online social network supporting Minecraft is immense providing an excellent resource for novice teachers like myself.

Despite its pixelated graphics and lack of gamed based instruction, critiquing Minecraft in relation to Gee's '36 Learning Principles' Thorn, 2013() highlights the effectiveness and appeal of the game. Firstly, Gee recognises that in relation to the development of problem solving skills, 'sandbox' games such as Minecraft enable gamers to explore within a protected environment. Secondly, effective digital games empower learners to become co-designers of their own learning – they are able to customize not only their learning experience but also domains within the game itself. Finally, the cost of failure is low. Minecraft particularly in creative mode where adversaries (such as zombies and creepers) are non-existent, allows students to experiment with alternative solutions, feel "pleasantly frustrated" (Gee, 2013, as cited in Thorn, 2013) by the challenges associated with the game and immerse themselves into the 'situated meaning" of the virtual Minecraft world. This cognitive immersion, according to Phillips et al. (2014) is a powerful motivating component to gaming. Cognisant of Csikszentmihalyi's theories regarding 'flow', gamers often lose themselves in virtual worlds feeling as if their own body has gone into the game space.

Improvements

Reflection is an integral component of my role as a teacher. At the completion of my Minecraft sessions, I was fortunate to be able to discuss the effectiveness of the classes with a teaching colleague. These discussions primarily revolved around the intriguing behaviour of the second group (my colleague did suggest that some of the behaviour could also be attributed to the fact that the session was the final class of the day!). In addition to these discussions, my own reflection regarding the structure of the activity and its implementation highlighted a number of issues which I believe would require modification before I again undertook a gaming for learning activity.

The key issues which arose from my reflections were:

Limitations of the Minecraft app – initially inspired to undertake the gravity experiment by the blog of US based science teacher Bob Kahn (www.middleschoolminecraft.com), I soon discovered that the Minecraft iPad app lacked a number the features associated with the desktop version of the game (for example, objects can-not be thrown and equipment such as levers, trapdoors and feathers are not accessible). These limitations necessitated alterations to the first model of my experiment. However, although initially frustrating, I believe these limitations actually increased the challenge for the Grade 6 students to negotiate.

Consolidating student learning – although my activity was aligned with ACARA documents, to consolidate the learning of the students further, the development of a group hypothesis to guide their science inquiry would be advantageous. Additionally, results could be correlated into statistical graphs or displayed on scaled geographic maps to integrate the session with other subject areas.

Time for student discussion and reflection – the time constraints associated with attempting to facilitate the activity with two Grade 6 classes restricted my ability to provide adequate time for student reflection at the completion of the session. One of the surveyed students suggested that to improve the activity "more time and more interesting things to test and explore" would be valuable. Ideally, groups would have utilized the Apple TV to showcase their structures to classmates. A whole class discussion would have enabled students to share their findings and to consider their results.

Monitoring off task behaviour – this is a particularly interesting issue because despite the sabotaging that occurred among some groups of students, the feedback from the majority of the students was that they had no difficulties during the activity. So although my initial reaction to this behaviour was that tighter regulation of student participation was necessary, most students did not appear offended or upset by the behaviour. However, this was a one off activity - would students still view sabotage lightly if a more detailed Minecraft activity was included in a larger unit of work? Introductory lessons regarding online behaviour expectations and structured consequences for misdemeanours would definitely be necessary if implementing a gaming for learning program.

(Nb: following the lesson I have learnt that players are able to block unwanted participants from their worlds by switching off the 'local server multiplayer' function)

Was my activity equitable? – As part of their study into this approach, Gerber et al. (2014) discuss the equitable components of their own experiments with game based learning classrooms. This discussion prompted me to consider whether my activity had in fact been equitable. Although school policy encourages all students to bring their own device to school a small number of students did not have their iPads with them for the session. Additionally as discussed previously, a minority of students did not have access to the Minecraft app. Were these students ultimately disadvantaged because they were unable to fully participate in the activity? There is no doubt that their effective engagement in the activity was negatively impacted. Confirming prior to the activity that all students had Minecraft loaded onto their iPads or alternatively, arranging for school devices to be available for student loan would have facilitated the inclusion of all students.

Conclusion

Conclusively, my investigation into the effectiveness of Minecraft to teach scientific concepts has revealed that the adaptability of the game enables teachers to implement a wide range of game based activities to compliment the Australian science curriculum. In addition to core scientific topics such as physics and biology, Minecraft particularly lends itself to teaching students about ecology and sustainability practices. The open-ended nature of the game encourages students to demonstrate their creativity through building, exploring and collaborating with their peers.

The positive feedback received from the participants in this project strongly indicated that implementing digital games in the classroom was engaging for the students. This style of student-centred learning empowers students to apply their knowledge of digital technologies to their classroom based learning. Students are engaged in experiential learning which utilizes a range of tools and skills with which they are well acquainted. As the 'Quest to Learn' website acknowledges “these games not only engage students in the learning process, but also allow teachers to assess students in real time and provide feedback on the learning experience immediately” Quest To Learn, 2015(). As Hayes and Gee (2010, as cited in Robinson, 2014, p.33) persuasively proffer games are essentially “learning systems built around a popular culture”.

This project has however, left me with one lingering question. Research shows that the adoption of gaming for learning strategies continues to proliferate across the world. At the Viktor Rydberg school in Sweden, Bilton (2013) notes that Minecraft is now a compulsory learning tool. Game based learning is at the core of the learning experiences offered by the 'Quest to Learn' school in New York. But does making gaming compulsory within school take the fun out of it for the students? Conceivably, game based learning is popular among students because it is innovative and kind of feels like play. Popular games like Minecraft could lose their appeal with students if they are routinely used as instructional tools. Further research into the long term benefits of game based learning will hopefully reveal the answer to this lingering question.

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