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Investigating the role of Minecraft in educational learning environments

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ABSTRACT

This research paper identifies the way in which Minecraft Edu can be used to contribute to the teaching and learning of secondary students via a multiple case research study. Minecraft Edu is recognised as a gamification tool that enables its users to create and evaluate project-based learning activities within a classroom context. Learning through edugames was found to enhance learning as well as allow students to attain overall learning outcomes. This permitted an enhancement of engagement, collaboration, the creation of authentic learning activities as well as the attainment of learning outcomes. The role of the teacher was also found to play a considerable role in students attaining these twenty-first-century teaching and learning capabilities.

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Introduction

Technologies are a fundamental part of learning in today's classrooms. There is increasing dialogue and professional development to increase the technological skills of educators with the intention to use these skills in transforming their own classrooms. This coupled with the recent introduction of a national Australian curriculum which requires all Australian students to demonstrate particular competencies in key Capabilities (*aka Learning Across Capabilities*), specific twenty-first-century Learning is required for young people to be supported to become successful learners, confident and creative individuals, and active and informed citizens (Melbourne Declaration on Educational Goals for Young Australians, 2015). Thus, the key capabilities of the Australian curriculum which encompass knowledge, skills, behaviours and dispositions that, together with curriculum content in each learning area and the cross-curriculum priorities, will assist students to live and work successfully in the twenty-first century (ACARA, 2015).

Together, Bring Your Own Device (BYOD) and cloud computing are revolutionising classroom learning by removing existing physical and virtual boundaries (Parsons, 2014) as well as giving teenagers more purpose to own their own device and use it to its maximum capabilities (Johnson, Adams Becker, Estrada, & Freeman, 2014). BYOD programs have certainly

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played a role in the increase of the number of Australian teenagers as 82% aged between 14 and 17 years now own their own technological device (Raco, 2015).

NSW DET and schools are moving away from "traditional" Learning Management Systems such as Moodle, blogs and wikis and are moving towards using cloud-based platforms such as "Office 365 for Education" or "Google Apps For Education (GAFE)" for their teachers and students to create, retrieve, store and share information (Bernardo, 2012). Many primary and secondary schools are implementing BYOD programs by asking students to bring their own iOS-based device, windows-based device, chromebooks and other devices to be able to actively participate as a digital learner to achieve such capabilities (Song, 2014). Others are introducing mobile learning to reduce the digital and social gaps, reduce training time, increase the depth of learning and prepare students to enter the IT society of the twenty-first-century (Ghahfarokhi, Horri, & Dastgheibyfard, 2014).

It is essential for educational organisations, with its budget restrictions and sustainability challenges, to use cloud computing as it offers many benefits by providing the infrastructure, platform and educational services directly through cloud providers and by using virtualisation, centralised data storage and facilities for data access monitoring (Ghahfarokhi et al., 2014).

Edugames are recognised as being dedicated to supporting collaboration and learning in education safely and meaningfully. There is much research about using Minecraft in schools to support teaching and learning with many such as Al-Washmi et al. (2014) and Cosh (2015) paying particular attention to the engagement and how this edugame can be used in specific Key Learning Areas.

The purpose of this study was to examine how edugames, in particular Minecraft Edu, may enhance the learning processes in an Australian high school teaching and learning environment. This facilitates an identification of frameworks and guidelines that are needed to support positive learning behaviours associated with edugames. The study investigated whether Minecraft Edu can be used to pedagogically enhance curriculum in terms of the types of content that can be learned as well as positively enhance the learning behaviours of students enrolled in and completing Year 7 Technology Applied Studies (TAS) in a NSW secondary school.

Literature review

Gamification

Games are the ideal learning environment with their built-in permission to fail, encouragement of out-of-the-box thinking and sense of control (Kapp, 2015). Gamification has been defined as a process of enhancing services with (motivational) affordances in order to invoke gameful experiences and further behavioural outcomes (Huotari & Hamari, 2012). Games are regarded as experiences that provide meaning within a safe digital or non-digital environment that often have a clear set of boundaries and allow its players to explore, think and try things out (Kapp, 2015). Moreover, games are able to provide motivation to succeed and reduce the sting of failure (Kapp, 2015).

The main goal of gamification is to rise the engagement of users by using game-like techniques such as scoreboards and personalised fast feedback (Flatla, Gutwin, Nacke, Bateman, & Mandryk, 2011). Lee and Hammer (2011) define gamification as the use of game mechanics, dynamics and frameworks to promote desired behaviours. Gamification can be

used to determine certain behaviours or correct others which demonstrates the efficacy of using gamification in learning and in e-learning situations (Fogg, 2009).

There is no doubt that gamification is an important and powerful weapon in the arsenal for learning, marketing and behaviour change of any kind (Kapp, 2015), however, there is much controversy that exists surrounding the legitimacy of gaming in education (Dyer, 2013). Deterding, Dixon, Khaled, and Nacke (2011) emphasises that the affordances implemented in gamification have to be the same as the ones used in games, regardless of the outcomes learned in class. It must be noted that published works that claim that gaming has no place in education are dated and actually refer to games that no longer exist.

Minecraft and Minecraft Edu

Minecraft is one of the most popular games in the United States with over 100 million registered users (The Atlantic, 2014). It has received much acclaim because of its innovative concept and player-driven narrative (Marklund, Backlund, & Johannesson, 2013).

Minecraft is a java-based first person multiplayer sandbox game (Ekaputra, Lim, & Eng, 2013). Categorised as a virtual world game, Minecraft is a game about placing blocks in a grid-style matrix (Mojang, 2015), where players are required to gather objects to create environments at will (Ekaputra et al., 2013). Minecraft is a game that was created and published by Mojang. Minecraft is void of any traditional video game goals (e.g. accumulate points and complete the level) for the players to achieve, as it places a great amount of responsibility on its player to create their own personal goals (Marklund et al., 2013).

Minecraft Edu is a school-ready remix of the original smash hit game Minecraft, played by over 30 million people worldwide (Creativeme.co, 2015). It contains many additions to the original game that make it more useful and appropriate in a school setting (Creativeme.co, 2015).

General use of massive multiplayer online role playing games (MMORPGs)

Online games are a type of entertainment-oriented IT that is different from traditional task-oriented IT (Lee & Tsai, 2010). Today, individuals not only play games for personal gratitude but to share their experiences with others (Cohen, 2014). Interaction is considered one of the most important aspects related to optimal experience with computer games (Lewinski, 2000). Interaction is defined as the behaviour of communicating (Laurel, 1993). Thus, levels of interaction have grown dramatically and have led to the creation of general use of massive multiplayer online role playing games (MMORPGs); (Fuster, Chamarro, Carbonell, & Vallerand, 2014).

MMORPGs are a new paradigm in computer gaming (Yee, 2006). MMORPGs are fully developed multiplayer universes with an advanced and detailed visual and auditory world in which players create an individualistic character (Griffiths, Davies, & Chappell, 2004). MMORPG users are part of a persistent world of up to 2000 other concurrent users (Sony Online, 2003). MMORPGs articulate and quantify the motivations of players and provides the foundation to explore whether different sections of the player demographic are motivated differently (Yee, 2006).

MMORPGs also have multiple tasks that require different characters with different skills in order to complete a challenge or quest (Cole & Griffiths, 2007). This teaches gamers to

be dependent on one another, which reinforces their relationships, providing a good understanding of teamwork (Cole & Griffiths, 2007). MMORPGs can be accessed via numerous devices such as PC's, XBOX's, PlayStations, smartphones and more (Dingli & Seychell, 2015).

As an MMORPG, players use Minecraft as a platform to showcase their creativity by creating tours of user-built structures (Lastowka, 2011). Additionally, players use Minecraft's software as a locus for generating their own creative content both in the game and outside of it (Lastowka, 2011).

Educational use of games

It seems that, at their best, Educational Games (edugames) may enrich learning and the pedagogical use of technology (Hamalainen, 2008). This is due to the many challenges it contains and facilitates, such as different group-specific learning processes despite the scripted environment (Hamalainen, 2008). These games create synergistic opportunities of peer learning and collaboration (Miller, 2014).

In teaching and learning environments, affordances associated with edugames within a project-based learning (PBL) environment permit:

(1) Learner-centred environments
(2) Collaboration
(3) Curricular content
(4) Authentic tasks
(5) Multiple expression modes
(6) Emphasis on time management
(7) Innovative assessment (Han & Bhattacharya, 2001).

These affordances develop both social and cognitive abilities of students as a result of its essential unifying elements of asynchronous and text-based form of communication (Han & Bhattacharya, 2001). Additionally, these affordances may emerge when cooperative learning manifests as participants with a variety of different competencies work in a structured environment where they utilise each other's unique skill sets to solve a problem or complete an assignment (Marklund et al., 2013). Thus, digital games can promote genuine collaboration between users, and are, to some extent, similar to collaborative learning environments or collaborative working environments, where participants share information and learn from each other (Patrick, 2009).

Educators are slowly introducing edugames into their classroom due to the educational benefits which they offer (Patrick, 2009). Games in class permit students to construct knowledge, engage in authentic practices, enhance literacy skills and learn how to create "big ideas" (Williamson, 2009). Furthermore, they have the capacity to develop cognitive, spatial and motor skills and help improve ICT skills as well as be used to teach facts (e.g. knowledge, recall, rote learning or memorisation), principles (e.g. cause and effect relationship) and complex problem-solving, to increase creativity or to provide practical examples of concepts and rules that would be difficult to illustrate in the real world (Patrick, 2009). Each of these skills is mapped to the higher order skills of Bloom's Taxonomy which is imperative to extending students (Mishra & Kotecha, 2015).

Methodology

Context

This collective case study investigated the use of Minecraft Edu in year 7 to year 10 learning spaces in secondary school classrooms in one co-educational public school in Western Sydney. Students were guided through either a PBL module that spanned over one semester (six months) or via a Minecraft club that met for one and a half hours per week outside of school hours. Students who are not yet using Minecraft Edu at school were also surveyed.

Participants

A total of 168 secondary students from this school participated in the research study. In 2015, the school enrolled 1098 students, of whom 51% have a Language Background Other Than English (LBOTE) and 5% are Indigenous students. There is a fairly even distribution of male (53%) and female (47%) students enrolled. Of the 168 participants, 64% were enrolled in year 7, 23% were enrolled in year 8 and 13% were enrolled in year 10. Twelve per cent of those surveyed use Minecraft Edu as part of their TAS PBL and 30% are members of the Minecraft Club. The school has recently implemented a BYOD program which is used in all four 75-min periods daily. Students are able to access Minecraft Edu via their own devices.

Design

An online questionnaire was designed using Google Forms and access was given to students during classes randomly. Students who both use and don't use Minecraft were surveyed.

Two separate worlds were created on Minecraft Edu and were used to conduct this research. Minecraft Edu enables students to work and play in a safe and predator-free environment by enabling the teacher to pay a one-off fee for server software and player user licences (Minecraftedu.com, 2015). Minecraft Edu provides definitive spaces that only those with access details can use to login. It also permits the teacher to maintain administrative rights as they use the selected world which enhances the virtual world in real time.

A world for one year 7 TAS Multimedia class and one world for the Minecraft Club (after school club) were created prior to conducting the research. Scaffolds and specific instructions were communicated to students prior to accessing the virtual worlds. Students were encouraged to use the tools of gamification to collaborate, communicate and create. Students were able to blog their experiences afterwards by completing an online application. Photos and video footage taken by the student were uploaded onto the blog to support the writing efforts of the student.

The Minecraft Edu world for year 7 TAS was created to support the design process learned in class. Year 7 TAS uses PBL techniques to learn the principles of designing and building an ideal house using a variety of CAD softwares. Minecraft Edu is used in TAS to test the validity of the designs and determine the feasibility of building that structure.

This tool was selected to support twenty-first-century teaching and learning opportunities. Additionally they also support each level of the ACARA ICT Capabilities that students must attain in their education in Australia. Such activities support the varying cognitive and practical skill levels of students whilst giving them the scope to extend themselves by

demonstrating a deeper understanding of subject matter as well as demonstrating problem-solving and critical thinking skills as appropriate (P21.org., 2015).

Implementation

Student feedback surveys

Students in years 7, 8 and 10 accessed the online questionnaire via a link through their class Google Classroom during class time. Students also accessed the survey during the Minecraft Club.

Minecraft Edu

Students accessed the Minecraft Edu component of the PBL lessons in year 7 TAS over three cycles of 75-min lessons stemming over three weeks during Semester one. Students accessed Minecraft Edu in the Minecraft Club for one and a half hours once a week for one term. Students logged onto Minecraft Edu using an assigned username and password. One classroom teacher and the researcher took part in observing all students.

All students accessed Minecraft Edu via the MinecraftEdu Launcher that was manually installed on the student's device by the student themselves.

Data sources

Student feedback surveys

Students in years 7, 8 and 10 were asked to complete a 5-min online Student Feedback Survey via Google Forms. This survey was directly accessed from their Google Classroom and comprised of 5-point likert scales, closed and open-ended questions regarding student's general use of Minecraft as well as their perceptions towards using Minecraft in educational contexts (Diagram 1).

Teacher observations

All activity in Minecraft Edu (via year 7 TAS and the Minecraft Club) was observed by the teacher. The observing teacher has experience in using Minecraft and is well supported with resources and well networked with teachers (via the Microsoft Innovative Expert Educator

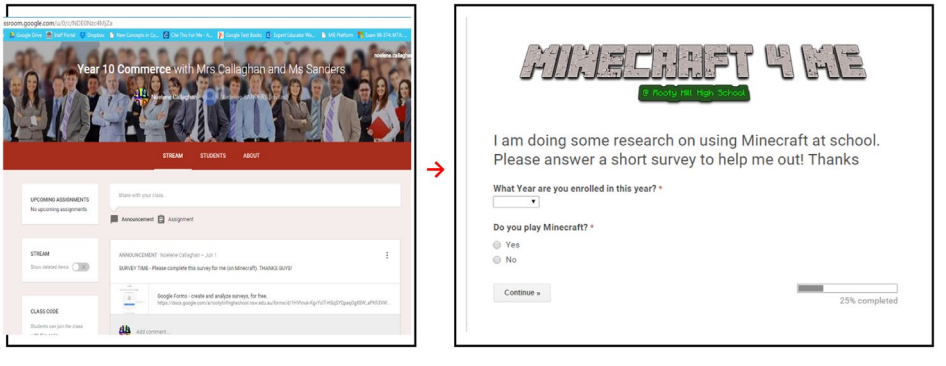

Diagram 1. Students accessing the survey via Google classroom.

Exchange) whom some are classified as experts in the space of Minecraft Edu. The observing teacher was provided with an observation framework to record classroom information data such as the classroom climate, student behaviours and student learning.

Researcher observations

The researcher observed all online activity in real time and used screen capture software (TechSmith Snagit) to record student contributions on Minecraft Edu. Particular attention was given to the collaboration, engagement and communication efforts of students, the ability to create authentic learning environments and how well students were able to connect separate tasks in their PBL. Together, all observers (Teacher and Researcher) monitored front and backstage behaviour permitting the identification of patterns surrounding gaming use in Minecraft Edu.

Student contributions to Minecraft Edu

Predescribed "worlds" were created prior to students accessing Minecraft Edu. All of the work created by students in their respective worlds were saved at the end of each session (lesson or club meeting). Video footage and screenshots were also taken by the student. Students were encouraged to periodically post a blog (using a standardised template) and support it with these own screen captures and videos allowing the researcher's findings to be more definitive (which can be found at http://callaghan-minecraft.blogspot.com.au).

Students were also encouraged to communicate on Minecraft Edu using standard text as one would communicate using an online chat tool. They are able to communicate to all online players or opt to chat privately to one or few online players. These conversations were logged, printed and used to support observer and researcher findings.

Activities were documented against cognitive affordances associated with students playing edugames with attention given to collaboration, the creation of authentic tasks, management of time and innovative assessment (Han & Bhattacharya, 2001).

Analytical approach

The nature of the multiple data sources used permits large quantities of information to be captured and validated against each other (Yin, 2009). Concerns of case studies surround their objectivity (Hodkinson & Hodkinson, 2001) and, in this study concerns were limited to the large number of contributions that were required to be analysed. Strategies were implemented to maintain continuity of findings and promote impartiality by:

- Using predefined learning material (for year 7 TAS) using PBL.
- Using two worlds (one for year 7 TAS and one for the Minecraft Club).
- Using predefined observation and survey instruments.
- Recoding contributions for all participating students (student communications via Minecraft Edu and the Student Feedback Surveys).

Furthermore, triangulating researcher observations with teacher observations reduced the potential for speculative reporting, thus enhancing the reliability and validity of findings (Johnson & Christensen, 2008).

Results

Overall student activity and behaviour

Both initially and throughout the study, teacher observations indicated that students were excited to be using Minecraft Edu. Students did not encounter any problems installing or locating Minecraft Edu, accessing their account or navigating in their predescribed world. Immediately, students showed signs of gaming skills. Of those who completed the Student Feedback Survey, 68% stated that they have previously/currently played Minecraft. When playing on Minecraft socially, students are more likely to build (65%), have fun (25%) and to a lesser extent mine (5%) and hunt for fun (4%). None of the students surveyed stated that their main purpose of playing Minecraft was to grief.

Of those students who played Minecraft outside of school, 84% declared that they possess higher than average skills (scored themselves a three or higher out of five on a likert scale) when playing on Minecraft, compared with 93% of students who use it at school (in year 7 TAS or in the Minecraft Club). Overall, 72% of those students surveyed believe that there are educational benefits of using Minecraft Edu in class.

Of those who participated in the observation component of the research, 62% used Minecraft Edu as part of their teaching and learning (in year 7 TAS) and 38% played Minecraft Edu in the Minecraft Club. Experienced gaming behaviours were also recorded by the Observer as all students who used Minecraft Edu could access the Minecraft Edu Launcher, connect to the server and login without any teacher intervention. In the Student Feedback Survey, all students reported that Minecraft Edu mirrored Minecraft enabling them to navigate in the game independently.

The Minecraft Club was observed to use the social tools of Minecraft Edu more than the year 7 TAS class as they used the text function more and appeared to be working autonomously on creating structures than those in a classroom environment. Interestingly, it was also noted by both the Teacher and the Observer in both groups that the more vocal (verbally) the students, the more productive students were in building structures collaboratively. Both the Observer and Teacher identified the main differences between the two groups of students as tablulated below (Table 1):

Differences were also found in the online survey in the perceptions of Minecraft between players and non players of the game. Interestingly, although the Minecraft players could foresee the educational benefits of using Minecraft and how it would assist them to attain goals in many key areas of their schooling as well as their career path, only a small group referred to the architectural aspect of the game, whereas the remainder discussed how Minecraft allowed them to attain twenty-first-century learning skills of collaborating with their peers, problem-solving, critical thinking and being creative.

Table 1. Key difference between year 7 TAS and the Minecraft club.

Year 7 TAS	Minecraft club
Completed task as assigned by the teacher without any modifications	Completed the task as assigned by the Group Leader however, would modify it to suit their own personality
Students often looked to one student as the leader and asked them for their support/OK to complete a build or to check if the build was suitable	Students worked equally in pairs or individually
Were concerned about negative play (destroying, griefing, etc)	Were not concerned about negative play
Did not use text in Minecraft to communicate (students communicated verbally)	Used text in Minecraft to communicate

Table 2. Differences in perception of the educational benefits of Minecraft by Minecraft players and non players.

Players	Non players
State that Minecraft could assist them develop their learning in specific KLA's such as Visual Arts, Maths, Science and TAS	Are more likely to view Minecraft as a social game with no educational purpose and consider the game to 'waste time'
Believe that using Minecraft in class could assist them in being a digital learner	Feel that they cannot play Minecraft (outside of school) due to their high school commitments
See it as a way to gain a more in-depth understanding of computers	Believe that Minecraft could not assist them academically and have no interest in trialling the game socially
See it as a way to be engaged in class	Have concerns of becoming addicted to Minecraft
Understand how the additional components (such as Mods) could be of benefit to support learning opportunities	Generally don't see what Minecraft can offer besides 'building with blocks'

Those who did not believe that Minecraft could assist them in learning were quite insistent on their decision as tabled below (Table 2):

Most importantly, none of the observers reported any incidences of misuse of the edugame or reported foul play, griefing, cyber bullying or intimidation. Additionally, no reports of such instances were reported by students.

Collaboration

The underlying purpose of using Minecraft is to collaborate with others (French, Stone, Nysetvold, Hepworth, & Red, 2014). In very small instances do users opt to play as a single player rather than as a multiplayer (Ellis, 2014). This research study observed the different behaviours between those in a teaching and learning setting (the year 7 TAS class) and those in a social setting (the Minecraft Club) and found that genuine collaborative working environments emerged. In both worlds, the Teacher and the Observer found that students shared information, communicated with one another and created objects collaboratively.

Although leaders emerged in the year 7 TAS class, students worked as an entire class (3 groups in the class) to problem solve and generate their digital community. As found by Marklund et al. (2013), students were observed to utilise each other's unique skill sets to solve a problem or complete a build. This was apparent when students were required to modify their structures as they found that their original build was incorrect and much the buildings were to be destroyed. Further, it was also observed that students were very generous in sharing their expertise in how to create a structure and let those whom possessed the most skill lead them in the build. It was also observed that the more vocal the students, the better they worked as a group in attaining lesson outcomes.

In the Minecraft Club, students tended to work in small groups (up to five people) or in pairs. Whilst they also collaborated with one another, they were more likely to inform one another of their specific skills and not actually assist their peer in developing those particular skills.

Students also commented in their feedback survey on how Minecraft Edu allowed them to collaborate with their peers, with one student stating the following:

> It supported our learning because we had to think and communicate with people in our class. I realised that we are learning with them and it was important to help them with what they needed help with. It was fun because of the way we were able to do our work.

The collaborative efforts of students played a key role in students completing work and attaining learning outcomes.

Attaining learning outcomes

Using games in the classroom is one learning technique to attain learning outcomes (Voulgari, Komis, & Sampson, 2014). It was found through observation and through assessing the e-Folio's that all students were able to attain learning outcomes by using Minecraft Edu to support their PBL in TAS. This PBL provided students with the opportunity to personalise their classwork and use self-assessment and peer reflection strategies to manage and complete their own work.

In reference to Bloom's Taxonomy, all students were observed in applying higher order skills of "create" and "evaluate". This is of particular importance in PBL as it has the potential to extend gifted and talented students as well as support those students who don't often accomplish these higher skills (SOURCE). The teacher reported that in year 7 TAS, students who commonly demonstrate the lower order skills were able to demonstrate these higher skills. The Teacher further stated that overall students were more excited and engaged to complete their work with Minecraft Edu than in other stages on their PBL.

Students supported their teacher's observations by commenting on how they felt that Minecraft Edu helped them in attaining their learning goals;

> It supports my learning because I can complete my whole project as though I am building it and this is what happens in real life. (Student A)
>
> This activity helped me determine if my design would work. It helped me see problems with my design and help me make a building for our city. (Student B)
>
> This activity taught me how to build things/make things on Minecraft, how to play Minecraft, how to use technology like this, and how to work together if you're building thing together. It helped me understand the design principles that we learned in class. (Student C)
>
> This supports our learning by letting us communicate with others in our class and seeing the way that they build which is important to help me build my house. (Student D)

Both the teacher and her students expressed that Minecraft Edu played a critical role in students creating an authentic task as well as reaching the desired outcomes.

The creation of authentic tasks

Minecraft permits students to create authentic tasks by communicating with others outside of their own personal space (Han & Bhattacharya, 2001). In year 7 TAS, Minecraft Edu allowed students to turn their semester-long PBL of researching and investigating the design elements and process of designing their dream home (using a number of technological resources including an e-Folio and Google Sketchup) and transforming it into an actual architectural structure in Minecraft Edu. This permitted students to ascertain if their structure met the design principles learned in class. It was observed by both the Teacher and the Observer that once students began building their ideal home in Minecraft Edu, they were able to quickly visually identify any flaws in their design and make necessary modifications on their Google Sketchup designs before proceeding with their build in Minecraft Edu. The inclusion of Minecraft Edu enabled students to demonstrate a more thorough understanding

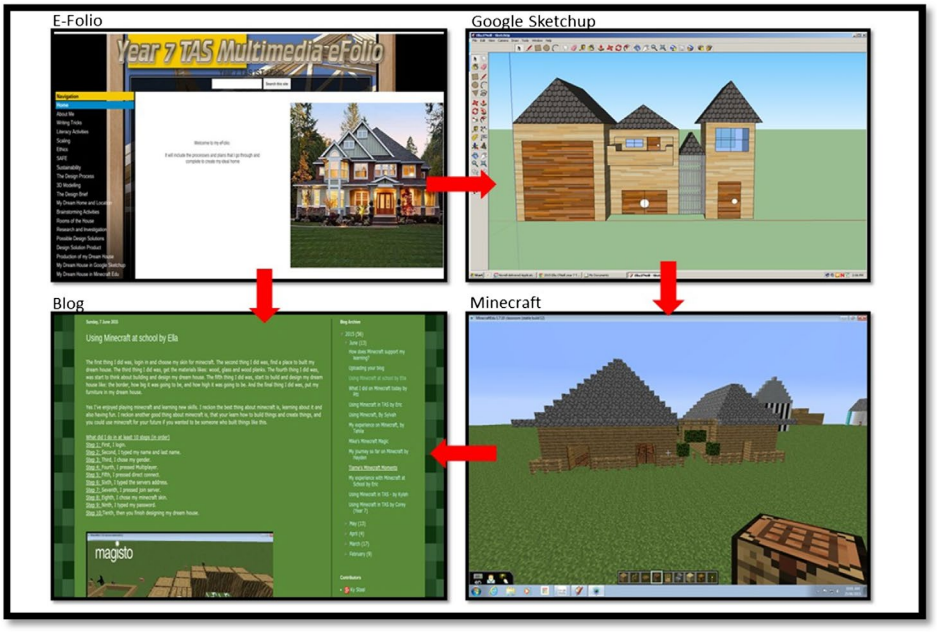

Diagram 2. Connections made between all of the technological components of the PBL.

of their project whilst attaining their learning and assessment outcomes. The observing Teacher had noted that the inclusion of Minecraft Edu had perhaps contributed to students in this class achieving a higher overall grade than they would have received without it. She further added that Minecraft Edu provided more learning opportunities to students within this class and provided students, particularly those with learning difficulties, different perspectives of how to complete their PBL.

Students in year 7 TAS were able to make connections between their PBL work in their e-Folio and their builds in Minecraft Edu. Ninety-eight per cent of students were observed to make connections in their e-Folio by linking their design planning process, Google Sketchup design, their Minecraft Edu build and blog entries to demonstrate how they linked ideas, drew on content, evaluated and created new information. Below (Diagram 2) is an example a students work and how they have connected ideas between all of the components in the PBL;

Further, students commented in the Student Feedback Survey that using Minecraft Edu would help them to create authentic tasks as it would help them be a better digital learner, help them learn more about computers and technology as well as see it as a way to be engaged in class.

Management of time

If play time is managed correctly, students are provided with unique opportunities to plan, revise and reflect on their learning through edugames and PBL (Han & Bhattacharya, 2001). This provides them with adequate support to create meaningful dialogue and work in a relaxed physical space (Petrov, 2014). Minecraft Edu can be used to facilitate more self-directed learning (Blaschke & Brindley, 2015).

As reported by 24% of non players, concerns surrounding becoming addicted to the game or having a lack of time was a major contributing factor to not play Minecraft in one's own free time. The observing Teacher also reported that prior to the implementation of Minecraft Edu, one of her initial concerns was that students would not use the time in class wisely, however she and the Observer did not notice any time wasted during the lesson. On the contrary, the teacher felt that by using Minecraft Edu as a tool in class, students were more productive, more engaged and more willing to complete their set tasks.

Students in year 7 TAS demonstrated proficient self-directed learning skills in all of the twelve lessons. The observing Teacher also reported that she felt redundant at times during the class as students took control of their learning immediately. These students were observed by the researcher to follow the lesson instructions and complete all tasks sequentially, resulting in completing more class work, making more connections between tasks and producing better researched e-Folio's.

Student engagement

Levels of student engagement in both worlds were extremely high. Anticipating that engagement would be high in the Minecraft Club, attention was given to observing and documenting the behaviours of students in year 7 TAS.

Both observers found that students were extremely keen to commence their work in Minecraft Edu as soon as they entered the classroom. As students became more confident with the edugame, the teacher was required to turn the server on *after* giving instructions and delivering the initial part of the lesson. Once the server was turned on, students very quickly and easily logged on and began working together. It was observed by both the teacher and the observer that the class climate had positively changed and that students were working together online. This was further supported by a student's comment in the feedback survey:

> Minecraft Edu supports my learning as it lets me design my house and by being able to play with others in my class. It is also good for my learning because we work as a team and are building places in Sydney.

The Teacher commented that the overall engagement level of students had significantly increased when using Minecraft Edu as part of the PBL module. She also stated that this edugame acted as a motivation for students to do well and to complete their initial planning stages of their designs so they could "play" on Minecraft Edu. This supports the notion that PBL is a comprehensive instructional approach to engage learners in sustained, cooperative investigation (Bransford & Stein, 1993).

The role of the teacher

The role of the teacher played a critical role in both world settings. Her active involvement online and having a virtual presence contributed to the engagement and motivation of students.

In year 7 TAS, the teacher logged into Minecraft Edu as a teacher player and actively used Minecraft Edu with her students. She also connected her laptop to the classroom projector

Diagram 3. Teacher online with students.

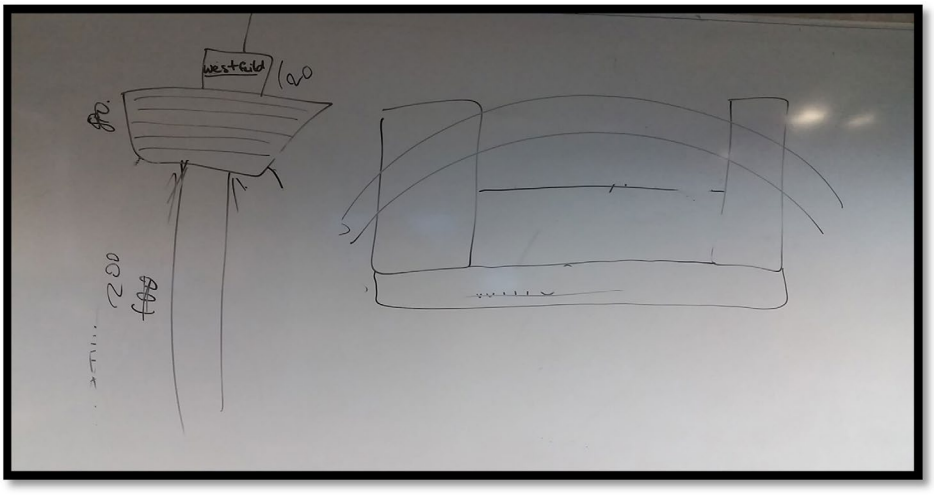

Diagram 4. Student design preparation and collaboration.

and displayed the world to her students. She too, participated in traditional gaming behaviours of texting/chatting, building and hunting (see Diagram 3);

It was observed that students were very eager to "show" their teacher what they had constructed and often asked her to follow them around virtually. The teacher reported that students felt privileged when they were followed and a video or screenshot was taken of their work. Such activities prompted other students to complete their work in an attempt to attract their teacher's attention. The teacher felt that relationships had strengthened as a result of being online with her students. Such behaviours were also observed by the Observer.

When adjustments needed to be made to structural buildings, the majority of students happily made the corrections by collaboratively designing and calculating the measurements

of the modified structure using the whiteboard and then creating that build on Minecraft Edu (diagram below). It was found that these students were more likely to link different components of their PBL/e-Folio together than those who did not want to modify their work (Diagram 4).

Students were forthcoming with their designs and deliberated about the specific elements of the build in context with the design principles learned in class before constructing it on Minecraft. Such behaviours enabled them to be continuously engaged, attain their lesson outcomes and work towards attaining assessable outcomes.

Discussion

This study has found that the use of edugames, in particular, Minecraft Edu in high school classes will contribute towards students developing their cognitive skills, being more engaged and creating authentic learning tasks. Observations made in both the year 7 TAS and the Minecraft Club found that students were able to use the software without any assistance regardless of whether they have had any experience with the game previously. Students were accepting of the parameters set the by the teacher and worked within the world that was created for them (i.e. a flat world in creative mode as opposed to the other options available). Although major differences between the two groups emerged once they began using Minecraft Edu, students still collaborated with one another which led to them attaining personal or learning goals.

There were very few differences overall between those who used Minecraft Edu socially and those who used it for learning purposes. Those who used it for learning purposes were less likely to ask for *mods* and other Minecraft tools (such as Netherlands) to be added to their virtual world, whereas the year 7 TAS class accepted their world as created by the teacher and appeared to view it purely as a learning resource. Most importantly, no negative gaming behaviours were noted throughout the research study.

Collaboration is a key component on Minecraft Edu which certainly enabled students to work together in unique learning spaces as found in year 7 TAS. Although patterns of behaviour differed between the two groups (year 7 TAS and Minecraft Club), all students worked with one another to create and build their structures. Students were observed to collaborate in both their virtual and physical space by planning and creating their work which mirrors similar behaviour that takes place in traditional teaching and learning activity on the completion of classroom tasks. Further, the collaborative nature of this task enabled students to develop their cognitive skills by using their higher order skills or create and evaluate.

Minecraft Edu gave students the capacity to be more engaged. This was observed as all (100%) of students overall remained on task during each lesson and by classroom observers who reported that they strongly disagreed that students were disengaged. It was also observed that those students who displayed higher engagement levels took ownership of their own learning and made more connections. Moreover, students also reported that they felt more engaged when the Minecraft Edu component of their PBL was introduced than previously.

Minecraft Edu enables students to create authentic learning tasks. The role of Minecraft Edu in the e-Folio assisted students to deeply synthesise their understanding of the design process learned in class. Additionally, almost all (98%) students in year 7 TAS were found to

make links between content in their e-Folio's and Minecraft Edu. As each student demonstrated higher order thinking skills, students were also found to perform activities of sharing information, planning information, and constructing content when using edugames.

Interesting findings surround the role of the teacher. Although she possessed sound Minecraft skills, her students did not ask for her technical assistance but used her as a source to verify the quality of their work. Her role was purely to facilitate their learning and to provide assistance to her students as requested. Further, the teacher had no impact on how engaged students were with Minecraft Edu or their ability to direct their own learning or work collaboratively as this occurred automatically.

Future research

The small scale of this research study is considered to be its major limitationand is not disregarded but recognised as providing a pathway for future research as a larger scale study would enable more reliable generalisations to be made. The use of similar methodologies will investigate how to provide effective professional development and may involve recognising and implementing taxonomies of learning. Such knowledge would not only empower students in their learning, but also empower teachers and educators in their delivery of content material. Future research could investigate the use of Minecraft Edu on a larger scale as well as ascertaining if the use of coding in the classroom could further enhance findings.

Conclusion

It was found in this study that Minecraft Edu contributed to the enhancement of classroom learning. Collectively the factors of the students experience with the game, the capacity to collaborate as well as the role of the teacher contributed to a learning environment where students can be more engaged and more committed to their own learning whilst attaining learning outcomes. This permitted an observation of learning and contribution levels in two groups of students which led to the development of students' cognitive capabilities in their application Minecraft Edu. This suggests that edugames such as Minecraft Edu may accommodate the varying learning abilities of students and may encourage teachers to use these technologies without apprehension.

Disclosure statement

No potential conflict of interest was reported by the author.

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