Conference Theme

The conference organisers have chosen the theme ImpaCT to underpin the Australian Council for Computers in Education 2018 conference. The theme acknowledges the most important effect on student outcomes - the impact of the educator.

While the hype associated with technology in education has emphasised ways in which information and communication technologies (ICTs) are ‘revolutionising’ the classroom, as educators and researchers we know that it is the educator who has the greatest capacity to impact student learning outcomes. These proceedings are being made available in a single PDF file which will be available from the conference website.

The refereed papers published in these proceedings have been accepted for publication following double-blind review of the full papers and subsequent revisions. The editors extend their gratitude and that of the conference committee to all the reviewers listed below for their time, energy and dedication to the task.

Debra Bourne and Leanne Cameron (Editors)

Peter Albion
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Table of Contents

Early Childhood Educators’ Attitudes towards Use of Digital Technology in Young Children’s Learning (refereed) Leigh Disney, Gretchen Geng ................................................................. 2
Investigation of Young children’s Use of Gestural Interface (refereed) Leigh Disney, Gretchen Geng .... 10
Exploring Social Regulation in Minecraft (refereed) Roland Gesthuizen, Matthew Harrison, Ibrahim Latheef ....................................................................................................................... 17
Cognitive and noncognitive skills acquired through two collaborative e-learning projects (non-refereed) Bruce Lander, Eiji Takeda .................................................................................................. 38
Tapping LMS data: Student participation in "preparing-for-the-test" discussion forums (non-refereed) Dorothy Langley .................................................................................................................. 39
Interface, interaction and interactivity: understanding ImpaCT of technology in classroom from a Cultural Historical Activity Theory perspective. (refereed) Ibrahim Latheef ........................................................................................................... 40
Pedagogical practices of K-12 online global collaborative educators (refereed) Julie Lindsay ............ 54
Self-impact & My-Impact: Teacher professional learning through social media(refereed) Sarah Prestridge ............................................................................................................................ 69
Integrating 3D Printing with Teaching at Monash College (refereed) Shannon Rios ....................... 83
High Impact Learning and Teaching using 3D Design and 3D Printing in Primary School Makerspaces (refereed) Michael Stevenson .................................................................................................................. 93
Digital Literacy and Gen Z. The Unpacking of Expectations (refereed) Vicki-Lee Tyacker ............. 107
Early Childhood Educators’ Attitudes towards Use of Digital Technology in Young Children’s Learning

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Introduction

Within the scope of digital technology is the concept of educational technology, which ‘is the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources’ (Orey, McClendon & Branch, 2009, p. vi). In earlier years (late 1930s-1960s), the common form of technology was the media of films and television, which was only used in higher education environments. The impact of these technologies on university education is the simple fact that they could be used within an educational setting (Hedberg & McNamara, 2002). Since the 1970s, digital technology started to be used in primary and middle school environments in Australia; and some individual teachers began to explore the relationships between technology and learning, although most teachers did not embrace the ideas of implementation of digital technology into classrooms. Nevertheless, the understanding of the tools of mass media and the entertainment industry were seen as providing an awareness to different students so that the students would be provided with practice and understanding of the skills and would be more appropriately kept in pace with the technology advancement (e.g. Ausburn & Hedberg, 1981; Maggs & Ray, 1985). Moving forward, digital technology appeared as instructional technology or computer based learning (Hedberg & McNamara, 2002). Moreover, digital technology is concerned with a wide range of media, including software and hardware development (McDougall & Boyle, 2001), exploration of new and different approaches to teaching and learning with digital technology (Romeo & Walker, 2001); multimedia, teleteaching and web-based teaching and learning (Allan & Ainley, 2000; Herrington & Knibb, 1999; Winter, 2001). Further more academic researchers (e.g. Franklin & Peat, 2001; Hedberg & McNamara, 2002) have conducted different studies to consider the strengths of diversity of various digital technology in teaching and learning.

The above indicates that digital technology has been co-opted into teaching and learning for a long period of time, and many studies have been conducted of using them effectively in educational environments so that their negative potential is averted and their positive potential is boosted within school or university learning environments. However, most research were focused only in the school or university education system, and very limited study has been undertaken about the use of digital technology within early childhood education environment, such as home, childcare or kindergarten. Part of the reason that there are limited studies done on the use of digital technology in early childhood settings is that it is not recommended that children under the age of three use computers. In that children younger than three learn through their bodies: their eyes, ears, mouths, hands, and legs and that the developmental skills of these children are learning to master are crawling, walking, talking, and making friends (Haugland, 2000).

In realistic terms, it is the educators of young children who will determine if children are exposed to digital technology within the early childhood learning environment. Therefore, the attitudes early childhood educators have towards use of technology and their corresponding ability to teach with digital technology will determine which technology children will be exposed too. Attitudes have been addressed as linking affective domains to reactions; hence attitudes influence behavior (Lee, 2005; Venkatesh, Morris, Gordon & Davis, 2003; Venkatesh, Thong & Xu, 2012). Educators’ attitudes towards teaching with technologies are strongly associated (Lee, 2005).

Moreover, due to the relative lack of confidence of many early childhood educators and parents of early childhood aged children in their knowledge of the use of digital technology; there often is a resultant pedagogical practice of ‘teaching the way you were taught’, hence diminishing opportunities for new
pedagogical opportunities (Perry et al., 2008). This includes the concern that children will not get exposure to new technological tools that may assist learning.

The use of digital technology within early childhood settings is a controversial topic and one that creates debate amongst those with stakes in early childhood education (policy makers, early childhood directors and educators, as well as parents). As stakeholders they will act as a filter to children’s access to digital technology, determining the exposure that children will have and scaffolding the way it is used.

**Methods**

**Participants**

Researchers contacted several child care centres with ethics clearance, and twenty early childhood educators in three child care centres in Australia participated in this research. Out of the twenty early childhood educators, 3 (15%) were male, and 17 (85%) were female. Seventeen participants provided their ages, ranging from 18 to 59 years old. The majority of the educators had been working from 2 months to 60 months (5 years).

**Instruments**

A survey was developed and administered to the participants. There are four sections in this questionnaire.

In the first section, the participants were asked to tick the media devices owned by the child care centre. The devices television, cable television (Foxtel/Austar), DVD player/Blue Ray player, a laptop or desktop computer, video game console like an Xbox, PlayStation, or Wii, handheld video game player like a GameBoy, PSP, or Nintendo DS, Smartboard, Smartphone, video iPod or similar device, Kindle, Nook or similar e-Reader, iPad or similar tablet device, and Internet were listed. The listed devices were based upon the study from Funk et al. (2009). The participants were also given an opportunity to list any other devices.

The participants were also asked to respond to the questions by placing a √ in the appropriate box/es or typing/writing numbers in identifying the media devices they used in the child care centre and the number of times the devices were used by their children attending the centre. The participating educators were asked to choose the number of times the media device from the following categories: Has never been used, yearly, at least once a semester, monthly, weekly, and daily. The categories were based upon the study of Funk et al. (2009).

In the second part of this section, educators were asked to placing a √ in the appropriate box/es about the 5 statements regarding the use of digital technology. The statements were developed based upon Chen and Chang (2006), Fogarty et al. (2002), and Li (2006). The participants were asked to rate their agreement using the following scale: Strongly disagree, disagree, unsure, agree, and strongly agree. The statements were (a) in terms of educational value, do you believe that the implementation of digital technology into early childhood is an urgent priority? (b) are you enthusiastic regarding the integration of digital technology into your service? (c) do you agree that the potential use of digital technology enhances the educator’s ability to teach? (d) do you agree that funding is sufficient to incorporate digital technology into your child care centre? and (e) do you agree that in the next five years your child care centre will have integrated more digital technology devices than you already posses? The 5 point scale was followed: 1 = strongly disagree, 2 = disagree, 3 = unsure, 4 = agree, and 5 = strongly agree.

The participating educators were also asked to identify the most important reasons for integrating digital technology into child care centres. Four possible reasons based upon the studies of Chen and Chang (2006), Fogarty et al. (2002), and Li (2006) were provided: (a) familiarising children with the world of new technologies, (b) the curricular benefits, (c) the recreational value to the child, and (d) parental expectations. Some participants might be aware of other reasons besides these identified four reasons; therefore, an opportunity to provide other reasons was provided for the participants.

The participants were then asked about whether in-service training for early childhood educators in the use of digital technology from four categories: mandatory and done annually, mandatory and done when new
digital technology is introduced, optional for staff, and not necessary. In the following part of this section, educators were asked to provide their attitudes towards the use of digital technology in teaching literacy, numeracy, science and physical education to 3-4 year old children. The 5-point scale was used: 1 = strongly disagree, 2 = disagree, 3 = unsure, 4 = agree, and 5 = strongly agree. Educators were also asked to provide their attitudes towards the use of digital technology to promote 3-4 year old children’s development in the domains of cognitive development, gross motor skills development, fine motor skills development, language development, and social development. The 5 point scale was used: 1 = strongly disagree, 2 = disagree, 3 = unsure, 4 = agree, and 5 = strongly agree.

Procedure
Consent was obtained successfully for the site directors with ethics approval. The questionnaire survey was administrated with the assistance from the child care centres. The site survey was undertaken from August to September. Survey instruments, in hard copy, were handed out to the participants and collected from the participants later with the assistance from the directors of the child care centres.

Results
Access the media devices in centres
The present study was conducted in three child care centres, two centres (Centre A and Centre B) from South Australia (SA) and one centre (Centre C) from Northern Territory (NT). Table 1 presents the number and percentage of the children who had been given access to the media devices in different care centres.

Table 1: Access the digital devices within child care centres/classrooms (percentage)

<table>
<thead>
<tr>
<th>Device</th>
<th>Centre A (n = 6)</th>
<th>Centre B (n = 8)</th>
<th>Centre C (n = 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Television</td>
<td>0</td>
<td>87.5</td>
<td>0</td>
</tr>
<tr>
<td>DVD player/Blue ray player</td>
<td>0</td>
<td>75</td>
<td>0</td>
</tr>
<tr>
<td>Computer (laptop or desktop)</td>
<td>100</td>
<td>87.5</td>
<td>0</td>
</tr>
<tr>
<td>Internet</td>
<td>100</td>
<td>62.5</td>
<td>0</td>
</tr>
<tr>
<td>Smartphone</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Video games (e.g., Xbox, Playstation, or Wii)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Video iPod or similar device</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Handheld video game player (e.g., GameBoy, PSP or Nintendo DS)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>iPad or similar tablet device</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cable television (Foxtel/Austar)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Kindle, Nook or similar e-Reader</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Smartboard</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Note. N = 20
For the five devices (television, DVD player, computer, Internet and Smartboard), the participating directors and educators in SA were asked to choose from a 6 point scale (1 = have never been used, 2 = at least once a year, 3 = at least once every six months, 4 = at least once a month, 5 = at least once a week, and 6 = at least once a day) in the number of times the media devices were used by the participating children in the child care centres in Centres A and B. It was found that the five devices were used at least once every six months in the child care centres/classrooms in Centres A and B (see Table 2).
Table 2: Access the digital devices within SA child care centres/classrooms (means)

<table>
<thead>
<tr>
<th>Device</th>
<th>Mean</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Television</td>
<td>3.29</td>
<td>1.64</td>
<td>14</td>
</tr>
<tr>
<td>DVD player/Blue ray player</td>
<td>3.15</td>
<td>1.75</td>
<td>14</td>
</tr>
<tr>
<td>Computer (laptop or desktop)</td>
<td>3.79</td>
<td>2.22</td>
<td>14</td>
</tr>
<tr>
<td>Internet</td>
<td>3.57</td>
<td>2.07</td>
<td>14</td>
</tr>
<tr>
<td>Smartboard</td>
<td>3.14</td>
<td>2.57</td>
<td>14</td>
</tr>
</tbody>
</table>

Note: N = 20

Attitudes about use of digital technology (e.g., Internet, educational software, television programs, educational apps etc.) within early childhood settings

This section reports the participants’ educators’ opinions about the use of digital technology in early childhood education from the following areas: (a) educators’ view towards digital technology is an urgent priority, (b) educators’ view towards digital technology’s integration in child care centre, (c) educators’ view towards digital technology's enhancement of educators’ abilities to teach, (d) educators’ view towards funding to incorporate digital technology into child care centres, and (e) educators’ view towards future use of digital technology.

Table 3 shows that the educators and directors agreed that (a) digital technology was an urgent priority; (b) digital technology should be integrated in child care centre; (c) educators’ abilities to teach should be enhanced; and (d) digital technology should be used in the future. It was also noted that educators believed that there is not enough funding to incorporate digital technology into child care centres.

Table 3: Educators’ view towards digital technology (means)

<table>
<thead>
<tr>
<th>View</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educators and directors' view towards digital technology is an urgent priority</td>
<td>3.35</td>
<td>1.18</td>
<td>20</td>
</tr>
<tr>
<td>Educators and directors' view towards digital technology's integration in child care centre</td>
<td>3.65</td>
<td>1.14</td>
<td>20</td>
</tr>
<tr>
<td>Educators and directors' view towards digital technology's enhancement of educators' abilities to teach</td>
<td>3.85</td>
<td>0.75</td>
<td>20</td>
</tr>
<tr>
<td>Educators and directors' view towards funding to incorporate digital technology into child care centres</td>
<td>2.65</td>
<td>1.04</td>
<td>20</td>
</tr>
<tr>
<td>Educators and directors' view towards future use of digital technology</td>
<td>3.65</td>
<td>0.75</td>
<td>20</td>
</tr>
</tbody>
</table>

Note: The means were presented using a 5 point scale anchored (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree).

The participating educators were also asked to provide the reasons for integrating digital technology into child care centres. Four set reasons were provided for the educators to choose and they were also allowed to add any other reasons.

The four provided reasons were (a) familiarising children with the world of new technologies, (b) the curricular and educational benefits, (c) the recreational value to the child, and (d) parental expectations.

Table 4 presents the percentages of the 4 reasons. It was found that educators agreed that “familiarising children with the world of new technologies”, “the curricular and educational benefits” were the main
reasons for integrating digital technology into child care centres, and they also agreed that “the recreational value to the child” and “parents expectations” were not the reason for the integration.

Table 4: Reasons for integrating digital technology into child care centres (percentages)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Familiarising children with the world of new technologies</td>
<td>85</td>
<td>15</td>
</tr>
<tr>
<td>The curricular and educational benefits</td>
<td>85</td>
<td>15</td>
</tr>
<tr>
<td>The recreational value to the child</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>Parental expectations</td>
<td>10</td>
<td>90</td>
</tr>
</tbody>
</table>

Note: N = 20

Attitudes towards training for educators in the use of digital technology

It was found that directors and educators in all the centres agreed that it was important for educators to be trained in the use of digital technology, \( p = ns \).

Attitudes towards the use of digital technology for teaching literacy, numeracy, science, art and physical education

Table 5 shows that the most educators thought that use of digital technology could be used to teach literacy, numeracy, science, and art, and physical education in early childhood education.

Table 5: Educators opinions about the use of digital technology teaching literacy, numeracy, science, art and physical education (Means)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numeracy/mathematics</td>
<td>4.30</td>
<td>.73</td>
<td>20</td>
</tr>
<tr>
<td>Literacy/language</td>
<td>4.30</td>
<td>.73</td>
<td>20</td>
</tr>
<tr>
<td>Science</td>
<td>4.20</td>
<td>.77</td>
<td>20</td>
</tr>
<tr>
<td>Art</td>
<td>4.10</td>
<td>.91</td>
<td>20</td>
</tr>
<tr>
<td>Physical education</td>
<td>3.40</td>
<td>1.14</td>
<td>20</td>
</tr>
</tbody>
</table>

Note: (a) The means were presented in order, from highest to lowest, using a 5 point scale anchored (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree). (b) A repeated measures ANOVA on the above means revealed a significant effect, \( F (4, 76) = 13.45, p < .01 \).

Table 6 presents the percentages of educators’ opinions attitudes towards the use of digital technology for teaching literacy, numeracy, science, art and physical education.

Table 6: Educators’ opinions about the use of digital technology teaching literacy, numeracy, science, art and physical education (percentages)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numeracy/mathematics</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>55</td>
<td>40</td>
</tr>
<tr>
<td>Literacy/language</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>55</td>
<td>40</td>
</tr>
<tr>
<td>Science</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>55</td>
<td>35</td>
</tr>
<tr>
<td>Art</td>
<td>0</td>
<td>10</td>
<td>5</td>
<td>50</td>
<td>35</td>
</tr>
<tr>
<td>Physical education</td>
<td>0</td>
<td>30</td>
<td>20</td>
<td>30</td>
<td>20</td>
</tr>
</tbody>
</table>

Note: (a) All above figures represents percentages within each item. (b) 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree
Attitudes towards the use of digital technology for children’s development in the domains of cognitive development, gross motor skills development, fine motor skills development, language development, and social development

Table 7 shows that the most educators thought that use of digital technology could be used for children’s cognitive development, fine motor skill development and language development, social development, and gross motor skills development.

Table 7: Educator’s opinions about the use of digital technology for children’s development in the domains of cognitive development, gross motor skills development, fine motor skills development, language development, and social development (Means)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive development</td>
<td>4.40</td>
<td>0.75</td>
<td>20</td>
</tr>
<tr>
<td>Language development</td>
<td>4.10</td>
<td>1.02</td>
<td>20</td>
</tr>
<tr>
<td>Fine motor skills development</td>
<td>3.95</td>
<td>1.15</td>
<td>20</td>
</tr>
<tr>
<td>Social development</td>
<td>3.65</td>
<td>1.14</td>
<td>20</td>
</tr>
<tr>
<td>Gross motor skills development</td>
<td>3.25</td>
<td>1.25</td>
<td>20</td>
</tr>
</tbody>
</table>

Note: (a) The means were presented in order, from highest to lowest using a 5 point scale anchored (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree). (b) A repeated measures ANOVA on the above means revealed a significant effect, $F (4, 76) = 9.14, p < .01$.

Table 8 presents the percentages of educators’ attitudes towards the use of digital technology for children’s development in the domains of cognitive development, gross motor skills development, fine motor skills development, language development, and social development.

Table 8: Educators’ opinions about the use of digital technology for children’s development in the domains of cognitive development, gross motor skills development, fine motor skills development, language development, and social development (percentages)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive development</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>45</td>
<td>50</td>
</tr>
<tr>
<td>Language development</td>
<td>5</td>
<td>30</td>
<td>20</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Fine motor skills development</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td>45</td>
<td>35</td>
</tr>
<tr>
<td>Social development</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>55</td>
<td>35</td>
</tr>
<tr>
<td>Gross motor skills development</td>
<td>5</td>
<td>15</td>
<td>10</td>
<td>50</td>
<td>20</td>
</tr>
</tbody>
</table>

Note: (a) All above figures represents percentages within each item. (b) 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree

Discussion and Conclusion

The present study reported the early childhood educators’ survey findings from the participating child care centres in SA and NT in Australia. Twenty educators participated in the survey. The majority of the educators had been working from 2 months to 60 months (5 years).

In regards to children’s access to digital technology in child care centres, it was found the children were provided access to some media devices such as television, DVD player, computer, Internet and Smartboard. This finding is consistent with the existing literature such as Perry et al (2008) that early childhood educators do not use a lot of available digital technology in their classrooms. Partially it was because of the funding provided by the child care centres; however, it was noted in this study that educators needed training to use and teach with these technologies.

Educators were asked to provide attitudes about use of digital technology within early childhood. It was found that educators agree that digital technology was an urgent priority, digital technology should be integrated in child care centres, educators’ abilities to teach should be enhanced, and digital technology
should be used in the future. This result agrees with the statement that digital technology can be used as instructional technology in educational settings (Hedberg & McNamara, 2002).

Educators agreed that “familiarising children with the world of new technologies”, “curricular and educational benefits” were the main reasons for integrating digital technology into child care centres, and they also agreed that “parents expectations” were not the reason for the integration. Educators agreed it was important for educators to be trained in the use of digital technology. The present study is consistent with Orey et al (2009)’s conclusions that educators need practice to facilitate learning and improving their performance of using digital technology.

In addition to the above findings, this study also found some other findings in relation to the use of digital technology in different curriculum areas as well as young children’s development. For example, educators’ attitudes towards the use of digital technology for teaching literacy, numeracy, science, art and physical education were reported. Most educators agreed the use of digital technology could be used to teach literacy, numeracy, science, art and physical education.

Moreover, this research also studied the educators’ attitudes towards the use of digital technology for children’s development in the domains of cognitive development, gross motor skills development, fine motor skills development, language development, and social development. Most educators thought the use of digital technology could be used for children’s five domains developments. This findings is consistent with the statement that digital technology can help with children achieving effective outcomes and improve the process of human learning (Australian, society for Educational Technology, 1975).

There are some limitations of this research. This study was conducted only in three child care centres in two states in Australia. Only twenty educators participated in this research. Therefore, further study has been developed already to conduct an online questionnaire survey to more early childhood educators in all states and territories in Australia to find more information about the educators’ attitudes towards use of digital technology in child care centres and how to target professional development programs to train the early childhood educators.

References


Investigation of Young children’s Use of Gestural Interface

Leigh Disney, Monash University, Melbourne
Gretchen Geng, Teaching and Researching Australian English and Culture, Melbourne

Introduction

In the past few years there has been a proliferation of new digital technologies into the field of education. Potentially the best known and most popular of these are Apple i-Devices (Falloon, 2013; Melhuish & Falloon, 2010; Siegle, 2013). Consumer studies show that Apple’s iPad is the most commonly owned tablet computer within Australia (Colley, 2010; Kennedy & Nadin, 2014; Tootell, Plumb, Hadfield, & Dawson, 2013). According to Kucirkova, Messer, Sheehy, and Fernández Panadero (2014), since their release in 2010, iPads and associated Apps have become popular worldwide for a variety of users, including preschool children. Mobile and tablet technologies are part of children’s lives (Chaudron et al., 2015; Highfield, 2014). A tablet computer is a gesture-based mobile computer which allows the user to manipulate software via physical interactions (Anderson et al., 2004). The website Apple Inc. (2011) explains that the iPad ‘features a large, high-precision, touch-sensitive display that requires no physical force, just simple contact with its surface’.

During the preschool years there is a shift in muscular development of fine and gross motor skills from the general to the specific (Harwood, Miller & Vasta, 2008). Children are able to refine motor skills leading to higher outcomes. Within the early years fine muscle development is slower than gross motor development, hence a need for a practice of such skills (Dodge, Cloker, & Heroman, 2002). Thus, whilst motor refinement progresses during the early years, there are still limitations for early childhood researchers; for example, the analysis of children’s artefacts to measure comprehension may be an inaccurate measure. For example, a preschool-aged child may have an idea in mind, but not yet possess the necessary fine motor skills to accurately represent this via an artefact (e.g. drawing), so the artefact does not reflect the child’s true knowledge (Marotz & Allen, 2013). Hence, the instruments early childhood educator’s use with children in the early years need to be cognisant of their developing fine motor control. Therefore, in relation to the aforementioned developing fine motor skills of children within the early childhood age range, the use of gestural interface devices is an appropriate choice for the current study and links appropriately with the theory of embodied cognition.
An important concept within the current research is the link between cognition and physical actions. Specifically, that action plays a central role in perception, acquisition and thought and that cognition is grounded in action (Rubichi, Riggio, Gherri & Nicoletti, 2011; Taylor, 2014). This notion finds relevance in the theory of embodied cognition. This form of cognition is founded on the claim that bodily-rooted knowledge involves processes of perception that fundamentally affect conceptual thinking (Barsalou, 2008; Segal, 2011). Embodiment suggests that individuals engage with their environment using their bodies to interact with stimuli in a manner that helps the mind to lessen the cognitive load required of tasks (Wilson & Golonka, 2013).

The embodiment literature highlights that cognitive activity involves sensory-motor stimulation (Barsalou, 2008; Brouillet, Ferrier, Grosselin & Brouillet, 2011). Research shows that when individuals come into contact with stimuli they automatically simulate the sensory-motor response to that stimulus. As the stimuli is perceived and acted upon it creates a positive response in the individual’s perception of the stimuli, influencing their affective judgement (Brouillet, Heurley, Martin & Brouillet, 2010; Jeannerod, 2006; Scorolli & Borghi, 2007; Taylor, 2014; Zwaan, 2008). Furthermore, when there is compatibility between the motor requirements of the stimuli and the motor response of the individual there are gains in reaction time known as Action Compatibility Effect [ACE] (Glenberg & Kaschak, 2002). For example, research has shown that ACE generates a genuine affective reaction that is positively marked (Cannon, Hayes & Tipper, 2010).

Early childhood pedagogies acknowledge that actions and bodily experiences are fundamental to cognitive processing, consistent with the concept of embodiment, whereby the young child learns through physical actions within the environment (Wellsby & Pexman, 2014). Educational approaches and theorists, such as Montessori and Piaget (cited in Berk, 2013), assert that physical movement and touch enhance learning. Therefore, it is important to understand why repeated physical actions can influence cognitive understanding.

The overall selection of apps when using new digital technologies such as gestural interfaces must also encompass a comprehension of how the new digital technology can most effectively be used to maximise potential human computer interactions (HCI) (Wigdor & Wixon, 2011). In their book, Wigdor and Wixon (2011) describe what they believe to be the key elements to designing software appropriate for gestural interfaces, including contextual environments, spatial design, seamlessness, scaffolding, no touch left behind and the autonomy of a gesture. There is a range of gestures associated with gestural interface devices it is therefore important that children can perform these gestures to maximise engagement and learning. Research conducted by Stone, Aziz, Sin, Batmaz and Chung (2014) measured the gestures that children two to four years of age could manage whilst using iPads. The gestures measured were: tap, drag/slide, free rotate, drag and drop, pinch, spread and flick. Their results indicated that 100% of 4 year olds could perform all of the gestures, as the children’s age decreased the percentages of children’s ability to perform all of the tasks also decreased. In an analysis of 100 commercial Apps aimed at two to three year old children, research by Nacher, Jaen, Navarro, Catala and Gonzalez (2015) highlighted that 99% of Apps used tap gestures and 56% used on tap and drag gestures as their only supported operations. However, Nacher et al. (2015) also advise that even young children are capable of more complicated gestural controls than most Apps allow for. Therefore it is important to consider both the content of that software and how the software utilises the interface it is designed for; thereby giving educationally appropriate information and utilising the mode of delivery to maximise children’s engagement and learning potential (Goldin-Meadow, Cook, & Mitchell, 2009; Kucirkova et al., 2014; Yelland, Gilbert & Turner, 2014).

There is not enough research informing early childhood stakeholders on the use, engagement and enjoyment that preschool children have with interactive screens, such as Apple’s iPad, and children utilising a gestural interface. Therefore, this paper is to investigate the use of gestural interface in early childhood settings and its impact on young children’s learning and engagement while playing iPads.

Methods
This research used qualitative research methodology and observation research method. Semi-structured field observation can be used as a “fundamental basis of all research methods” in social and behavioural science (Denzin & Lincoln, 2005).

**Participants**

Eighty children participated in this study. Children were classified as 3-4 years age group (43.8%), and 4-5 years age group (56.3%).

**Instruments**

The Involvement Scale *Assessing for learning and development in the early years using observation scales: Reflect respect relate*” (DECS, 2008, p. 81) was used and described nine signals that a child participating in an activity was indeed ‘involved’, they include: (1) concentration, (2) energy, (3) complexity/creativity, (4) facial expression and posture (non-verbals), (5) persistence, (6) precision, (7) reaction time, (8) verbal utterances/language, and (9) satisfaction. Concentration, energy, complexity/creativity and persistence are four essential signals that must be present for sustained, intense involvement.

Using the Gestural Interface App Rating Scale (GIARS) developed from the Haugland Scale (Haugland & Wright, 1997), 50 early childhood numeracy Apps were also chosen from the Game Centre component of the Apple website.

**Procedure**

Before this phase was undertaken, letters to the participants’ parents, letters to the directors and educators in child care centres were handed to the parents, directors and educators. Following this procedure, consent was obtained successfully from all parties.

All children participating in the proposed research were observed in three child care centres during their first use of the iPad2, and 5 times after for a total of 6 observations. Each observation is two-minute in duration, started at anytime whilst the child is using the iPad2 and continues. If the child leaves the iPad2 during the 2 minute observation period, the researcher continues to observe the child incase they come back to the iPad2. After a two minute observation, the researcher must take time to make notes and fill out the rating. Each observation requires a score sheet and label for each child for the 6 observations, based upon the Involvement Scale (DECS, 2008). The score sheets should not be recorded until after the observation is completed. SPSS will be used in data analysis. Data were transcribed, entered and analysed. The researcher took approximately 4 weeks to enter all the written answer in to the Statistical Package for Social Science (SPSS).

**Results**

Table1 presents the means and standard deviations of the nine areas in Involvement Scale. It was found almost all the areas other than verbal utterances and language were rated above medium engagement. Among them, the areas facial expression and posture, persistence and concentration were rated closer to high engagement. A repeated measures ANOVA was applied across the nine frequencies. A significant effect was evident (see Table 1).
Table 1: Engagement of Children’s Playing Apps (Means)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facial expression and Posture</td>
<td>2.90</td>
<td>.47</td>
<td>80</td>
</tr>
<tr>
<td>Persistence</td>
<td>2.83</td>
<td>.50</td>
<td>80</td>
</tr>
<tr>
<td>Concentration</td>
<td>2.80</td>
<td>.47</td>
<td>79</td>
</tr>
<tr>
<td>Reaction time</td>
<td>2.50</td>
<td>.57</td>
<td>80</td>
</tr>
<tr>
<td>Precision</td>
<td>2.39</td>
<td>.65</td>
<td>80</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>2.26</td>
<td>.51</td>
<td>80</td>
</tr>
<tr>
<td>Energy</td>
<td>2.23</td>
<td>.50</td>
<td>80</td>
</tr>
<tr>
<td>Complexity and Creativity</td>
<td>2.05</td>
<td>.37</td>
<td>80</td>
</tr>
<tr>
<td>Verbal utterances and Language</td>
<td>1.79</td>
<td>.64</td>
<td>80</td>
</tr>
</tbody>
</table>

Note. (a) The means are presented in order, from highest to lowest, using 4-point scale anchored (0 = no engagement, 1 = low engagement, 2 = medium engagement, and 3 = high engagement). (b) A repeated measures ANOVA on the above means revealed a significant effect, $F(8, 624) = 90.17, p < .01.$

The elements of Gestural Interfaces, including contextual environments, spatial design, seamlessness, scaffolding, no touch left behind and the autonomy of a gesture, was categorised if the child attempted to use elements of the gestural interface to assist with the cognitive load of answering the numeracy question. The following text shows an example of the Use Elements of GI:

Child No.7 was playing the App Monkey Numeracy. The App asked Child No.7 to complete a pattern: shell, jellyfish, shell, jellyfish, shell …Child No.7 pointed at each sea character in the question (the App calls out the name of the object), then she pressed the three alternative answers provided at the bottom of the screen: shell, jellyfish and clam (again the App calls out the name of the object). Child No.7 then repeated the question again pushing the three shells and two jellyfish, she finally placed her finger on the middle answer (jellyfish) and dragged it into the answer box. This indicated that Child No.7 was able to use the gestural interface elements to assist in solving the numeracy question posed of her.

The following presents an example of a child who did not use elements of GI:

Child No.63 was also playing the App Monkey Numeracy. The App asked Child No.63 to solve the equation of 1+2. It provided Child No.63 with a set of sea horses that the child could count in order to assist with the cognitive load. At the bottom of the screen were three potential answers: 3, 5 and 2. Instead of using the sea horses to count, Child No.63 placed her finger on the number 5 and dragged it into the answer box, when the App made an error noise and reversed the action; Child No.63 placed her finger on the number 3 and dragged it into the answer square receiving an affirmative response from the App. Therefore, the child did not use the gestural elements provided by the App to assist with the cognitive load, rather she used a trial and error approach or conversely she believed she already knew the answer, thus not needing the gestural interface cues.

It was also found the Elements of GI was significantly correlated with the following areas in children’s engagement scale (See Table 2). This result explains that when children use the gestural interface features they had higher levels of engagement in almost each area. This result clearly shows that educators and parents should encourage children to use the gestural interface device to maintain engagement within gameplay. This will require adults to scaffold children’s use of the interface to maximise the Apps’ potential.
### Table 2: Correlations between Elements of GI and Persistence, Concentration, Precision, Reaction Time, Satisfaction, Energy, Complexity and Creativity, Verbal Utterances and Language, and General Ranking

<table>
<thead>
<tr>
<th>Item</th>
<th>r</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistence</td>
<td>0.25</td>
<td>0.02</td>
</tr>
<tr>
<td>Concentration</td>
<td>0.26</td>
<td>0.02</td>
</tr>
<tr>
<td>Reaction time</td>
<td>0.59</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Precision</td>
<td>0.66</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>0.35</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Energy</td>
<td>0.23</td>
<td>0.04</td>
</tr>
<tr>
<td>Complexity and Creativity</td>
<td>0.39</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Verbal utterances and Language</td>
<td>0.26</td>
<td>0.02</td>
</tr>
<tr>
<td>General ranking</td>
<td>0.65</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

**Note.** N = 80.

### Discussion and Conclusion

This study contributes to the debate about the integration of digital technology, such as gestural interface, within the early childhood community and argues that such integration will provide developmental and learning benefits for young children.

When children used the gestural interface appropriately, they had higher levels of engagement. Anderson et al. (2004) state that a tablet computer is a gestural-based mobile computer, and it allows users to manipulate software via physical interaction, because it “features a large, high-precision, touch-sensitive display that requires no physical force” (Apple, 2011). That children showed higher levels of engagement when using the gestural interface suitably supports the statement that the use of gestural interface devices is an appropriate hardware choice for young children’s engagement during learning (Goldin-Meadow et al., 2009; Kucirkova et al., 2014; Yelland et al., 2014).

The gestural interface provided by iPads can be leveraged better with children’s learning needs (Wigdor & Wixon, 2011). Gestural interfaces allow for embodied interactions, which links appropriately to the way young children learn via gestures with their hands and fingers (Stone et al., 2014). Gestures such as finger counting are used by young children to comprehend as a problem solving tool (Wigdor & Wixon, 2011). This research also found the interactive designs of gestural interface devices are certainly appropriate for young children. With the developing capacities of children within the early years it is pertinent to note that as the children age the use of a gestural interface becomes easier and more effective. Children are able to refine motor skills, leading to higher outcomes (Dodge et al., 2002).

When evaluating emergent digital technologies such as gestural interface devices, embodied cognition explains that young children, via the use of their direct touch sensory inputs, maximise human-computer interactions (Barsalou, 2008; Brouillet, Ferrier, Grosselin & Brouillet, 2011). The use of gestures thereby benefitting learning in ways that previous standard desk/laptop computers could not. As a result, the acceptance of digital play as a pedagogical approach needs to be considered in the light of advances in technology. This finding is particularly important for parents, educators, policy makers and creators of digital technology.

It validates digital technologies, specifically the use of gestural interface devices, as appropriate tools for learning.

Therefore this has implications for early childhood stakeholders and the use of gestural interface devices with young children. The high levels of engagement displayed by children during the play phase strengthen the argument that gestural interface devices are indeed developmentally appropriate tools for use with
young children. These results suggest that gestural interface devices should be encouraged in early childhood service delivery.

How digital technologies are integrated, both in terms of hardware and software, needs to be considered for effective integration. Gestural interface devices and emergent technology prepares children for both their future educational and working lives (Daugherty, Dossani, Johnson, & Oguz, 2014). Educators therefore need training in the use of emergent technologies. Services should access or supply appropriate training to maximise staff confidence and ability to scaffold children’s learning in this area. There needs to be careful consideration in relation to which Apps are used with children, as many of the numeracy Apps available for children are not developmentally appropriate.

References


Exploring Social Regulation in Minecraft

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Matthew Harrison, University of Melbourne, Melbourne
Dr. Ibrahim Latheef, Monash University, Melbourne

Introduction

Over the past two decades, research has been undertaken into the different forms of social interaction observed between players engaged in virtual spaces, particularly in relation to online massively multiplayer role playing games such as World of Warcraft (Uz & Cagiltay, 2015; Chen, 2012). There appears to have been less consideration given to the processes by which multiple players regulate their collective activity (Panadero & Järvelä, 2015). Whilst there are many reasons why this has not been explored in the context of a digital game, other researchers are probably unsure what these regulatory processes would look like in a multiplayer game.

To help address this challenge, this exploratory study was undertaken to adapt an established coding scheme developed that coded interactions in a primary school Science classroom (Grau & Whitebread, 2012), and apply it to an example of a multiplayer mode of play in Minecraft. This supported the identification of possible instances of virtual social regulation in a digital gaming context, explored possible limitations and begin a wider discussion of the strengths and limitations of using this coding scheme in virtual or online spaces.

Conceptualising and capturing instances of social regulation

There has been a change in our perception of how the regulation of cognitive and metacognitive processes in learners are understood, particularly in the field of educational psychology. Regulation has traditionally been described as a process at the individual level, contained to the ‘self’, with a focus on the child’s own cognitions, emotions and behaviours (Hadwin, Järvelä & Miller, 2011). There has been a shift away from solitary models of self-regulation, towards a social understanding of an interplay between regulation at an individual level, and a co-constructed social level (Panadero & Järvelä, 2015; Hadwin, Järvelä & Miller, 2011; Volet, Summers & Summers, 2009; Vauras, Iskala, Kajamies, Kinnunen & Lehtinen, 2003). These theorists no longer conceptualise students as isolated silos. This change reflects the emergence of a socio-cultural model of cognitive development, emphasizing the essentially social nature of learning. This increased emphasis on social learning, particularly in regards to collaborative problem solving, has resulted in new models being devised to explain behavioural regulation within these group contexts.

Co-regulation is a regulatory process that is intended to influence the behaviour of one specific member of a group (Grau & Whitebread, 2012), which means that it is an exclusively bilateral process. This can be seen through a Vygotskian lens of an instructor-apprentice relationship, or expert-novice tutoring relationship. These relationships involve what Vygotsky (1980) classically described as the “more knowledgeable other” guiding a relatively less knowledgeable or skilled individual in solving an equation, or finding the right note on a musical instrument. Moving from a bilateral to multilateral conceptualisation of regulatory processes, Shared regulation is refers to ‘group planning, monitoring and regulation’ of a shared activity, characterised by multiple group members interacting with each other to achieve a common goal (Grau & Whitebread, 2012, p. 411). Despite this commonality of purpose, this form of regulation may still retain imbalances between participants in relative knowledge, skills and social capital (Hadwin, Järvelä & Miller, 2011).

There is a suggested interplay between these three forms of regulation, contending that all three are active, often simultaneously, in the collaborative planning, monitoring, regulation and evaluation of
group activities (Grau & Whitebread, 2012; Hadwin, Järvelä & Miller, 2011). Figure 1 below visually represents the relationships between self-regulation at an individual process, co-regulation as a bilateral process and shared regulation as a socially constructed co-process occurring during multilateral interactions. This present study is particularly interested in this third and most recently recognised form of regulation, ‘shared regulation’.

![Figure 1: A visual representation of the self and social levels of regulation (Harrison & Gesthuizen, 2018).](image)

As can be seen in Figure 1, both self and social levels of regulation are conceptualised as consisting of four sub-processes spanning the planning, regulating, monitoring and evaluating of behaviours. This focus on the social levels can also be attributed to the challenges of observing instances of regulation within a single individual. As a starting point for analysing the applicability of the coding scheme to a game-based environment, this present study is particularly interested in identifying instances of planning.

Self-regulation is a process that is notoriously difficult to observe, relying on the capture of ‘self talk’ during a solo activity or asking a student to reflect and comment on their own performance. This is why traditionally researchers have identified instances of these regulatory processes during joint activities by observing and analysing verbal and nonverbal communication between participants (Whitebread, Coltman, Pasternak, Sangster, Grau, Bingham & Demetriou, 2009). In the
last decade, researchers have increasingly relied upon audio and video recording as a tool for capturing a time and place, affording multiple sequences of event coding (Grau & Whitebread, 2012).

As noted by Panadero & Järvelä (2015), shared regulation is an emerging conceptualisation of these processes. This exploratory study presents a novel method for exploring social regulation through the analysis of publicly shared footage from multiplayer Minecraft games, specifically on a case study of co-regulation between two players. Like any emerging model, over the coming years it will inevitably be refined as it is exposed to a more rigorous critique. This exploratory study is a first step in a more comprehensive evaluation of this model.

Minecraft as a tool for collaborative creation

Minecraft was originally conceived by its developers as a simplistic sandbox game, where a player would freely create, locate and destroy objects called blocks. This form was known as a ‘Creative Mode’, that presented an open-ended space or virtual landscape to play and construct with no specific objectives or ending. The subsequent ‘Survival Mode’ was soon released, a mode of play that encouraged players to mine resources and construct fortifications to withstand the damaging advances of ‘creeps’, or challenging hordes of creatures. As Minecraft began to transcend its origins as a niche independent game project and became a mainstream cultural phenomenon, many game players focused their output almost exclusively on building, sharing and showcasing their creative designs. The addition of more sophisticated design components in subsequent updates to the game allowed players to add functions and automated macros to the static environment. These ongoing cycles of design modification and changing player behaviour have resulted in Minecraft evolving into a more complex space for collaborative creativity and expression. The development and release of Minecraft for Education was the first online foray by many teachers with their students onto a new and challenging landscape of social processes of play, learning and identity construction (Dezuanni, O’Mara & Beavis 2015) within the context of a virtual world. The socialisation in these virtual spaces afforded by online technologies appears to be self-organising and self-regulating (Gesthuizen 2012).

To explore the occurrence of social regulation within Minecraft, a publically shared ‘live streamed’ video was used as a preliminary exploration of the application of Grau and Whitebread’s (2012) framework. Many public recordings of Minecraft gameplay are freely shared online, inviting feedback and comment. As is now increasingly common within gaming culture, Minecraft players often capture and freely share a recording of their game session. The perspective shared within these online videos is often from the first-person point of view of a participating player. Their accompanying narration is often deeply personal and may widely vary in style and nature from shared laughter, dialogue with other players, to that coloured by profanities or filled with obscure jargon. Analysis of a case study video was used by the researchers to directly compare and contrast the nature of regulatory planning between the examples provided by Grau and Whitebread in the physical world and these virtual game-based environments. Exploring this artefact allowed for an exploration of how the social norms developed within an online group in this virtual environment impact upon how players may socially regulate their peers’ behaviours.

4.0 An approach to applying an established coding scheme

Whilst analysing player behaviour when playing an online game by analysing recorded dialogue has been done before (Chen 2012, Peña and Hancock 2006), the researchers were interested in applying a framework developed for observing social interactions from the physical world to a virtual environment. Transporting an established framework for observing social regulation can provide insights into instances of social regulation in a virtual space. It can also bring to light tensions and contradictions within the framework itself.
Grau and Whitebread’s (2012) coding scheme for collaborative interactions provides a delineation between four processes of regulatory activity including planning, monitoring, enacted regulation (viewed as modifying group behaviour) and evaluation. In order to set boundaries around the scope of the present study, this explorative case study focuses on just the planning, monitoring and evaluation processes. The category of process, enacted regulation, is reintroduced in discussions surrounding the future of this theoretical framework.

This scheme examines each category in relation to the completion of a common task, the socio-emotional components of the interactions, and organisational structure of the group. Using this as a lens to explore the processes involved with game-based collaborative interactions provides a structure for the analysis of the relationship between these three focus processes of social regulation within group activities. Tables 1 provides an overview of each of these respective processes, as well as the defining indicative behaviours that were used in the original study to identify instances of each process in Grau and Whitebread’s original study.

Table 1: coding scheme for capturing instances of planning, monitoring and evaluating processes within joint activities (Grau & Whitebread, 2012).

<table>
<thead>
<tr>
<th>Task</th>
<th>Planning the task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicative behaviours from coding scheme:</td>
<td>Talks about the relevant content knowledge that should be applied in the resolution of the task</td>
</tr>
<tr>
<td></td>
<td>Talks about his/her knowledge about strategies or personal resources that can be used in order to solve the task</td>
</tr>
<tr>
<td></td>
<td>Talks about setting goals</td>
</tr>
<tr>
<td></td>
<td>Establish task-specific goals that can be used to guide cognition and monitoring</td>
</tr>
<tr>
<td></td>
<td>Formulates a step by step strategy before solving a problem</td>
</tr>
<tr>
<td></td>
<td>Propose a way of solving the task or a way to start doing it.</td>
</tr>
<tr>
<td>Organisational</td>
<td>Planning the organisation of the group</td>
</tr>
<tr>
<td>Indicative behaviours from coding scheme:</td>
<td>Definition provided but no indicative behaviours listed: Students plans the organization of the task in a pragmatic level (who is going to do what)</td>
</tr>
<tr>
<td>Socio-emotional</td>
<td>Planning socio-emotional interactions</td>
</tr>
<tr>
<td>Indicative behaviours from coding scheme:</td>
<td>None provided as Grau and Whitebread reported they did not observe any instances of socio-emotional planning.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Task</th>
<th>Monitoring the task</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Indicative behaviours from coding scheme:</th>
<th>Talks about his/her understanding of the task</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Talks about things that he/she knows but does not remember (regarding the task)</td>
</tr>
<tr>
<td></td>
<td>Comments on how they are doing</td>
</tr>
<tr>
<td></td>
<td>Checks the progress of the task</td>
</tr>
<tr>
<td></td>
<td>Detects errors</td>
</tr>
<tr>
<td></td>
<td>Use his/her content knowledge to help the monitoring of the task</td>
</tr>
<tr>
<td></td>
<td>Ask something to someone else</td>
</tr>
</tbody>
</table>

**Organisational**

**Monitoring the organisation of the group**

*Definition provided but no indicative behaviours listed:* Students monitor the organisation of the task in a pragmatic level

**Socio-emotional**

**Monitoring socio-emotional interactions**

<table>
<thead>
<tr>
<th>Indicative behaviours from coding scheme:</th>
<th>Comments on his/her motivational/emotional state</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Talks about the reason for success or failure</td>
</tr>
<tr>
<td></td>
<td>Comments regarding the behaviour of a classmate</td>
</tr>
</tbody>
</table>
As can be seen in Table 1, the authors provide not just definitions, but indicative behaviours for each subcategory of process. The term indicative behaviour refers to a directly observable indicator of performance (Griffin & Care, 2014). As opposed to a definition stating how monitoring is commonly understood within the literature, an indicative behaviour for this process would describe what it looks and sounds like when a student is performing this process. It is rather sensible to use indicative behaviours when trying to identify the performances of these processes in a new context, as they help pinpoint what the observer should be searching for when coding video data. The use of these established indicative behaviours within this coding scheme serves two purposes. It provides an established framework for capturing and exploring instances of social regulation in collaborative play in Minecraft. In addition, it allows for the exploration of the boundaries and tensions within Grau and Whitebread’s (2012) when applied to a virtual environment. The following section explains the selection of the case and the method for applying this coding scheme.

**Selecting a virtual world for analysis**

To help test the application of Grau and Whitebread’s scheme in a virtual environment, a single exploratory case was needed to check whether this scheme was ‘fit for purpose’. A Minecraft gameplay session for this case study was selected by the researchers for this case study from a search of available public clips according to the following selection criteria:

Include sufficient audible dialogue that could be easily transcribed and coded and run for at least 10 minutes. Be publically shared and attributed using a creative commons licence.
The task should align with some types of interactions that might be seen in a classroom.

An initial viewing of online video clips revealed many instances of participants negotiating goals and strategies, checking and confirming understandings of knowledge and resolving conflicts. A mode of Minecraft gameplay entitled ‘Team Build Battle’ replicated some of the social dynamics found in classroom collaborative projects and will be the focus of this study. For this mode, several teams of players were challenged to construct something around a Halloween theme within a designated time limit and concluding vote as illustrated with Figure 2. When the build phase was completed, Minecraft teams could interact and review their work. It shares a team-based design with
an element of inter-team competition and coordinated construction of an object, as illustrated with Figure 2
6.0 Coding the gameplay interactions

The footage of a ‘Team Build Battle’ was coded in two distinct phases. In the initial phase, the action and narrative was independently and concurrently coded by two researchers for the three processes. Instances of planning, monitoring and evaluation behaviour were first identified and directly annotated onto a printed narration of the video footage. Each instance was then examined in context by a direct examination of the video footage. This formal codification of these instances was managed and compiled using the video analysis software StudioCode, as shown in Figure 3. StudioCode has been used in other contexts to analyse interpersonal interactions in physical environments (Clarke, Mesiti, O’Keefe, Xu, Jablonka, Mok & Shimizu, 2007). The results from each researcher during the two phases were then compared, contrasted and reconciled with the creation of hypertext links to the source material and the co-generation of a final dataset from the footage.
Figure 3: Coding regulatory activities in a publicly shared ‘Team Build Battle’, a mode of play in Minecraft.

When the adopted coding scheme was used to code the video, some interesting results emerged when analysing and contrasting the frequency of instances of planning in Case A:, as displayed in Table 2.

Table 2: Instances of planning, monitoring and evaluation in Case A

<table>
<thead>
<tr>
<th></th>
<th>Case A: Team Build Battle (Gamer Chad, 2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total video sample duration</strong></td>
<td>7m 02s</td>
</tr>
<tr>
<td><strong>Planning</strong></td>
<td></td>
</tr>
<tr>
<td>Number of instances of planning</td>
<td>33</td>
</tr>
<tr>
<td>Average duration of each planning instance</td>
<td>5m 54.00s</td>
</tr>
<tr>
<td>Percentage of total play time</td>
<td>43.36%</td>
</tr>
<tr>
<td>Total time of planning</td>
<td>3m 02.82s</td>
</tr>
<tr>
<td><strong>Monitoring</strong></td>
<td></td>
</tr>
<tr>
<td>Number of instances of monitoring</td>
<td>30</td>
</tr>
<tr>
<td>Average duration of each monitoring instance</td>
<td>03.54 s</td>
</tr>
<tr>
<td>Percentage of total play time</td>
<td>25.12%</td>
</tr>
<tr>
<td>Total time of monitoring</td>
<td>1m 46.38s</td>
</tr>
<tr>
<td><strong>Evaluation</strong></td>
<td></td>
</tr>
<tr>
<td>Number of instances of evaluation</td>
<td>24</td>
</tr>
<tr>
<td>Average duration of each evaluation instance</td>
<td>4m 14.00s</td>
</tr>
<tr>
<td>Percentage of total play time</td>
<td>23.46%</td>
</tr>
<tr>
<td>Total time of evaluation</td>
<td>1m 39.44s</td>
</tr>
</tbody>
</table>
The original video spans around ten minutes of online activity, but this includes the Gamer Chad branding and a welcome from the participating players at the beginning before play commences, and a subsequent team debriefing at the conclusion of play. This present study was interested in the seven minutes (422 seconds) of actual gameplay time. Within this period, the most frequently observed process was planning, with 33 individual instances consuming 43.36% of the total play time. Given the nature of the game mode, this is not surprising. The players began with a blank virtual landscape and were quick to reach agreement upon what they would attempt to construct within the allocated ‘Halloween’ theme. This initial planning sought to reach a shared agreement on both the desired artefact to be constructed and the division of labour.

Relatively less time was dedicated by the players to the monitoring of their play. At first glance this seems surprising given that 30 individual instances were recorded, which is comparable in frequency to the 33 instances of monitoring previously discussed. This perception quickly changes though when considering the difference in duration of playtime dedicated to monitoring compared with planning. The total playtime for this second process was only present 1m 46s of play, or 25.12% of total playtime, which is almost a full minute less than the aforementioned planning. This results in instances of monitoring recording that are of a significantly shorter mean duration than instances of planning. It is important to note that this does not necessary mean that the exchanges are less sophisticated. Whilst the short mean duration may represent less detailed player observations about performance, they may simply be more rehearsed at an individual level before being verbalised with the group.

Likewise, the lower frequency and duration of instances of evaluation may suggest that the players were first rehearsing their feedback at an individual level to ensure that the message was delivered in a way that was both meaningful to the other players and considerate of their socio-emotional responses. This lower frequency and duration of evaluation may also be a consequence of the focus of this present study exclusively upon the game play portion of the video. Foreseeably, the additional three minutes of post-build footage would afford more opportunities for player evaluation and reflection upon the events and outcomes of the just-completed Build Battle.

Whilst an analytical review of the frequency and duration of the three processes provides a comparative metric, it doesn’t explain why these instances are occurring. The interplay between these process is best understood when unpacking specific examples of planning, monitoring and evaluation from Case A.

**Exploring player behaviour through the lens of social regulation**

In order to further interrogate these results, it is required to understand the contexts in which planning was observed. The following tables highlights some examples that were observed in Case A for each indicative behaviour described by Grau and Whitebread (2012). Each of the three focus processes of social regulation are presented in their own table with corresponding indicative behaviours and examples from the Team Build
Battle. Following each table is a discussion of the contexts in which this example was observed, with particular attention paid to the antecedents and consequences of the interaction between the players.

This discussion does require a degree of interpretation. As previously noted, researchers believe there is a constant interplay between usually non-verbalised individual-level regulation, and publically shared social-level regulation. The dialogue between the players has first been processed and moderated at an individual level. Therefore this analysis uses the available contextual data to ‘fill in the gaps’ in inferring the motivations and intended outcomes behind each instance of regulation, but it is important to be mindful that these are only an interpretation.

Planning goals and actions within the team

After coding the video, the dialogue transcript highlighting instances of planning was carefully sampled to extract examples from the list of provided indicative behaviours. These descriptions of the target behaviours from Grau & Whitebread’s (2012) original scheme were aligned with examples of each respective behaviour from Case A, as shown below in Table 3.

Table 3: Examples of instances of planning processes within joint activities observed

<table>
<thead>
<tr>
<th>Indicative behaviour of Planning (Grau &amp; Whitebread, 2012)</th>
<th>Case A: Team Build example (Gamer Chad, 2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task Planning Task:</strong></td>
<td>“Okay, so we're doing trick or treat! Yay!” (Gamer Chad 2016 t=26s)</td>
</tr>
<tr>
<td><strong>Talks about setting goals</strong></td>
<td>“I want to do like a porch anyways” (Gamer Chad 2016 t=34s)</td>
</tr>
<tr>
<td><strong>Task Planning Task:</strong></td>
<td>“I am gonna put the door open OK and it's gonna be swinging, I like, you know, open towards your right or left or whatever” (Gamer Chad 2016 t=50s)</td>
</tr>
<tr>
<td>Formulates a step by step strategy before solving a problem</td>
<td>“So does it open inside the house? You would have build the person on this side. You know that it opens out, it opens outward, Yeah”</td>
</tr>
<tr>
<td>Task Planning:</td>
<td>“I don’t exactly remember honestly what a panda looks like so I'm doing them all but I can't and I can't remember. OK, I mean I know it's black and white but that's about all I know” (Gamer Chad 2016 t=3:05)</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Talks about his/her knowledge about strategies or personal resources that can be used in order to solve the task</td>
<td>“I know it’s cuz I figured what a panda it looks like, I think he has mostly white hair head doesn't he, uh yes with black accents” (Gamer Chad 2016 t=3:55)</td>
</tr>
<tr>
<td>Organisational Planning:</td>
<td>“What about the floor? Oh yeah, I think you've doing the floor. Yeah but I want to do the porch anyway. Okay but just like one high.” (Gamer Chad 2016 t=30s)</td>
</tr>
<tr>
<td>Players plan the organization of the task in a pragmatic level (who is going to do what)</td>
<td>“I'm really confused. Yeah, yeah. That's very dangerous right here, cuz I wanted to do like a porch area.” (Gamer Chad 2016 t=1:48s)</td>
</tr>
<tr>
<td>Socio-Emotional Planning:</td>
<td>None provided as Grau and Whitebread reported they did not observe any instances of socio-emotional planning.</td>
</tr>
</tbody>
</table>

At the start of the game, the players contributed to their experience by addressing the future video audience and breaking the fourth wall in this digital game (Bräysy, Arkö 2017). When talking about the scenario goals, the players would communicate the details of the challenge to focus a team towards the same mission, ask questions to ensure understanding, align personal goals or tasks. A player in Case A opened by stating that the team-build game Halloween based theme was *Trick or Treat* then another responded: “I want to do like a porch anyways” (Gamer Chad 2016 t=34s)

When considering the planning dialogue, it is interesting to note that players often struggle to reference a particular place or direction in a virtual world by using cardinal directions or gestures as their avatars do not have hands that can clearly point or arm motions to indicate size or layout.

This is reflected in the dialogue at some points in the build challenge. In this particular game they would often vocalise their planning decision and action by starting work on a particular object. Lacking cardinal directions, this can help align the attention and view point of other team members to face the same way.
Declaring a decision by a deliberate construction action to emphasise a point might seem provocative and presumptuous but in the context of a virtual world it makes sense when we consider that it would be relatively trivial and quick to build then demolish or undo if the idea is challenged or not accepted.

“I’m really confused. Yeah, yeah. That’s very dangerous right here, cuz I wanted to do like a porch area. (Gamer Chad 2016 t=1:48s)

The building objects in the game of Minecraft are generally comprised of large cubic blocks, a handy unit of measurement of approximately one metre that provides a handy reference for scale:

“Okay but just like one high.” (Gamer Chad 2016 t=30s)

“I think it is supposed to be five long” (Gamer Chad 2016 t=1:20)

At one point the narrative struggles to explain how a door will swing open or close without a clear indication what part of a building is inside and outside. This is again good illustration of the unique problem faced by online players who lack a common spatial reference system of directions and locations. Whilst common terms like left and right are relative to the observer but it is not always clear in a virtual world who is doing the talking and where they are standing in reference to you.

“I am gonna put the door open OK and it's gonna be swinging, I like, you know, open towards your right or left or whatever” (Gamer Chad 2016 t=50s)

Monitoring the team performance within the rules of the game

After coding the video, the dialogue transcript for monitoring instances was carefully sampled to extract examples of particular indicative behaviours. These are outlined in Table 4 alongside corresponding behaviour notes from Grau & Whitebread (2012)

Table 4: Examples of instances of monitoring processes within joint activities observed

<table>
<thead>
<tr>
<th>Indicative behaviour of Monitoring (Grau &amp; Whitebread, 2012)</th>
<th>Case A: Team Build example (Gamer Chad, 2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task Monitoring: Talks about his/her understanding of the task</td>
<td>“See this right here okay? Okay, so the door is gonna be like right here and open like that. Go in like this.” (Gamer Chad 2016 t=1:11)</td>
</tr>
<tr>
<td>Task Monitoring:</td>
<td>“I want to make sure it's big enough so it looks cool, like this is gonna be the door” (Gamer Chad 2016 t=38s)</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Task Monitoring:</td>
<td>“So does it open inside the house? You would have build the person on this side. You know that it opens out, it opens outward. Yeah” (Gamer Chad 2016 t=1:29)</td>
</tr>
<tr>
<td>Task Monitoring:</td>
<td>“I hope, so listen. This person's got to be smaller.” (Gamer Chad 2016 t=2:45)</td>
</tr>
<tr>
<td>Task Monitoring:</td>
<td>“Oh no! Does he look like a panda? This does not look like a panda.” (Gamer Chad 2016 t=3:43)</td>
</tr>
<tr>
<td>Task Monitoring:</td>
<td>“Ok, wait. I think it is supposed to be five long. Make sure that it is the right length”. (Gamer Chad 2016 t=1:20)</td>
</tr>
<tr>
<td>Task Monitoring:</td>
<td>“I don't exactly remember honestly what a panda looks like so I'm doing them all but I can't and I can't remember. Okay, I mean I know it's black and white but that's about all I know” (Gamer Chad 2016 t=3:05)</td>
</tr>
<tr>
<td>Organisational Monitoring:</td>
<td>“Dude, because your person's an adult right? Mine is just a little kid.”</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------------------------------------------------------------</td>
</tr>
<tr>
<td>Definition provided but no indicative behaviours listed: Students monitor the organisation of the task in a pragmatic level</td>
<td>I need to make mine bigger or is that good?” (Gamer Chad 2016 t=2:50) “OK so there's that and then we'll put his other arm down here to to his side.” (Gamer Chad 2016 t=3:32)</td>
</tr>
<tr>
<td>Monitoring socio-emotional:</td>
<td>“How's your big person coming. Good? I think good I think I’m doing doing well.” (Gamer Chad 2016 t=3:32) “clay clay clay!” (Gamer Chad 2016 t=1:02) “doo doo doo doo” (Gamer Chad 2016 t=6:27)</td>
</tr>
<tr>
<td>Comments on his/her motivational/ emotional state</td>
<td>“clay clay clay!” (Gamer Chad 2016 t=1:02) “doo doo doo doo” (Gamer Chad 2016 t=6:27)</td>
</tr>
<tr>
<td>Talks about the reason for success or failure</td>
<td>Comments regarding the behaviour of a classmate</td>
</tr>
</tbody>
</table>

When considering the monitoring dialogue, a player added an emotional inflection to their monitoring dialogue by repeating phases. Whilst this would be a source of annoyance in a real-life classroom, it may have been used to fill the silence or provide a tacit feedback to other team members that their work was being examined or looked at. In this game, it almost became at some points an almost musical overtone “clay clay clay clay!” (Gamer Chad 2016 t=1:02) “doo doo doo doo” (Gamer Chad 2016 t=6:27)

When players are puzzled or don’t remember something, they will carefully articulate and verbalise this confusion, even whilst they are busy constructing an object. This may be to help draw out information from another team member or to receive confirmation about their thinking. Considering that it is not possible to display a puzzled look on an avatar, it is not unexpected in a virtual environment for players to communicate and express their confusion by adding muttering noises or extra dialogue.

I don’t exactly remember honestly what a panda looks like so I'm doing them all but I can't and I can't remember. Okay, I mean I know it's black and white but that's about all I know (Gamer Chad 2016 t=3:05).
Evaluating team performance and progress

After coding the video, the dialogue transcript for evaluation instances was carefully sampled to extract examples of particular indicative behaviours. These are outlined in Table 5 alongside corresponding behaviour notes from Grau & Whitebread (2012)

Table 5: Examples of instances of evaluation processes within joint activities

<table>
<thead>
<tr>
<th>Indicative behaviour of Evaluation (Grau &amp; Whitebread, 2012)</th>
<th>Case A: Team Build example (Gamer Chad, 2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task Evaluation: Students evaluate the quality of performance</td>
<td>“.. that's good, I think that's really good” (Game Chad 2016 t=2:59)</td>
</tr>
<tr>
<td>Organisation Evaluation: Definition provided but no indicative behaviours listed: Students monitor the organisation of the task in a pragmatic level</td>
<td>“Okay, okay, we got this. A minute something left. Dude, dude, dude, dude. Yeah, it's good, let's go, this feels good. Okay um, wait, What time?” (Gamer Chad 2016 t=6:02)</td>
</tr>
<tr>
<td>Socio-Emotional Evaluation: Talks about/shows feelings regarding the task</td>
<td>“This is a big build I know but I just feel like people should like really, I mean like when people do bigger builds. Uh-huh, you have so much time” (Game Chad 2016 t=7:02)</td>
</tr>
</tbody>
</table>

Whilst there were fewer instances of evaluation behaviour in this game, there are several instances of evaluation using short phrases such as “I think that's really good” (Game Chad 2016 t=2:59). Considering that this particular game was a build activity that challenged players with time and creativity constraints, some of the language in this game is rich with often many ideas communicated that bundle punctuated points of information, feedback and feelings exchanged with each interaction. These complex layers of information are simultaneously layered into many conversational exchanges.

8.0 Discussion and future directions

Through this exploratory study, the researchers have identified that the Grau and Whitebread coding scheme is useful for providing both a tool for identifying and classifying observations of the processes and subprocesses within regulatory planning,
and it assists in understanding the potential motivations underpinning these processes. The provision of a common vocabulary, alongside the authors’ indicative behaviours, allows for a comparison between the frequency and nature of regulatory planning in physical spaces and in virtual environments. The use of these schemes to explore the potential motivations for these planning behaviours is also of great interest. Many of the examples observed by Grau and Whitebread in the Science classroom were present in the sampled Minecraft gameplay.

Self-regulation relies on being able to capture thoughts. Whilst listening to dialogue that has been passively recorded during a Minecraft game play may enlighten a researcher to what a player is thinking, this is still fundamentally different to an explicit instruction for a player to speak aloud, articulate and describe their thoughts as has been done in the science classroom. The dialogue and Jargon used in these games is emotional and complex, conveying many cultural clues about player thoughts and emotions. Socioemotional regulation requires individuals to have the vocabulary to express their emotions. The dialogue recorded during a Minecraft game may be heavily loaded with jargon, expletives and noises. It is reasonable to expect that a recording transcript may not capture the full range of emotions spoken by the players, giving undue emphasis to loud, public exclamations. Quieter emotions of surprise and curiosity would be difficult to articulate.

The scheme has helped to unpack the self and social regulation that occurs in online environments, providing new insights into the forms of online behaviour experienced within multiplayer games. We propose the following modified coding scheme for examining the planning, monitoring and evaluating behaviours that occur in online and virtual environments.

Exploring the behaviour of avatars controlled by players in a virtual landscape presented some unique coordination problems that would not be faced by a similar study of students in a science laboratory. The social presence and social cues shared by the avatar is significantly less than that of face-to-face interaction. This has been reported before with research examining the text analysis of computer mediated communications in computer games (Peña and Hancock 2006). As with many other online games, there is a problem within Minecraft that the sharing facial emotions, body language and gestures is problematic. There is evidence that online players can work around this by quickly adapt their language using a rich and colourful narrative to help regulate planning, monitoring and evaluation. In addition, as online players jointly building objects would lack a clear coordinate or spatial reference system, they can quickly adapt novel strategies such as jumping or building to indicate direction, size or intention.

This also begs the questions ‘Where to next?’ A logical next step is the further testing of this scheme with other modes of play within Minecraft, and subsequently multiplayer digital games in other genres. One consideration is ascertaining the relationship between physical location, game design and social regulation. Is there a difference between players engaging in online play and local multiplayer, where players are co-located in a shared physical space? If so, what is the role of game design in promoting social regulation?
In partnership with more expansive testing, there may also be a need for a coding scheme that builds upon the Grau and Whitebread’s work but developed with the specific contextual requirements of multiplayer digital gaming environment. Such a coding scheme would allow for the continued study of the social regulation of cognition, emotion and behaviour, and would also help in developing game design principles that promote such processes. An increased understanding of the relationship between the design of gaming components and their influence upon player interaction could have applications for developing games designed to develop collaborative social skills.

Although beyond the scope of this paper, it would be interesting to contrast these results with an equivalent Grau and Whitebread’s classroom science collaborative activity running for a similar duration. This comparison could provoke a number of pertinent questions: does the design of the virtual environment provoke more regulatory planning between team members, or do the affordances of the physical environment, such as communication through nonverbal body language, encourage an increased frequency of communication between participants?

Conclusions

The purpose of this exploratory study was to test the potential of applying an instrument developed for capturing instances of social regulation in one context and transporting it to another. Whilst this limits the generalizability and significance of the findings, our finding verify the general application of the Grau and Whitebread model beyond the science classroom to a virtual environment. Although this was trialed using just one video sample, the opportunities afforded through the use of this coding scheme soon became apparent, but so too did the limitations and areas of tension. It was apparent through findings that coding instances of social regulation can be a useful tool for exploring and understanding the collaboration and behaviour that occurs between players in virtual environments and simulations.

The Grau and Whitebread (2012) model provides a means for coding instances of social regulation within group activities. Whilst it has been used to examine collaborative interactions in science classrooms, this exploratory research seeks to hypothesise its applicability in a virtual environment or simulation. Through the use of the multiplayer sandbox game, ‘Minecraft’, the researchers have integrated the boundaries of the model with this exploratory feasibility study to create a framework helping to identify areas of opportunity and tension within the collaboration and creation experience.

This research will help educators better understand and inform their student behaviour in virtual environments so that they can design the best learning experience possible to stimulate critical-thinking and problem-solving. The findings suggests that coding instances of social regulation can be a useful tool for exploring and understanding the collaboration and behaviour that occurs between students in virtual environments and simulations.
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Volet, S., Summers, M., & Thurman, J. (2009). High-level co-regulation in collaborative learning: How does it emerge and how is it sustained?. Learning and Instruction, 19(2), 128-143.


Data Source and License

Video from [Game Chad] (2016, October 15) Minecraft / Trick or Treat in Team Build Battle / Gamer Chad Plays [Video file]. Retrieved from https://www.youtube.com/watch?v=KceNh4s2QKo

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Cognitive and noncognitive skills acquired through two collaborative e-learning projects

A/Prof Bruce Lander, Matsuyama University
A/Prof Eiji Takeda, Matsuyama University

Computers, music players, smartphones or tablets, youngsters of today seem to always be multi-tasking with one or more of these at the same time. Whether we like this or not, this is something that will only escalate with time. There is no doubt that this trend is having a huge impact on education (Martin et al, 2011). Up to now many students would probably not associate their mobile devices, at least in the Japanese context, with learning. However, if technology can be introduced to promote collaborative learning there is a far greater potential for autonomous learning to occur outside the classroom.

This paper presentation will introduce two projects that differ slightly in the way technology has been used to advocate autonomous and collaborative learning. The first project involves a collaborative e-learning exchange project between high school students in Japan and Australia sponsored by the Australia-Japan Foundation. Whereas the other project involves Japanese economics university students and how they have used ICT tools to communicate and learn collaboratively amongst themselves.

The theoretical framework which this study is based around includes Kolb’s “Experiential Learning” (1984), Gibbs’s “Reflective Cycle” (1988) and Ash & Clayton’s “Reflective Framework” (2005) which stress the importance of “reflection” in student learning. According to Kolb and Gibbs, “reflection” about learning is indispensable for students in terms of raising and maintaining motivation to learn.

Regarding the first project, students in Japan learning English, created 5 sets of multimodal digital stories introducing local and national cultural elements while their Australian counterparts did the same, but in Japanese. All digital stories were exchanged every 2 months over the course of one academic year. Students in Australia provided feedback online in English, whereas students in Japan did the same, but in Japanese. Student created eBooks were made with various forms of iPad apps including Comic Life, iMovie, PuppetPals, Tellagami and Book Creator for iPad. The second project however involves students from the department of economics at a medium sized private university in Western Japan and how they used ICT to collaborate and learn towards joint goals. Through the use of these edu-tech tools this paper will highlight the value of ICT usage in the context of foreign language education and students in the department of economics in recent times. It was discovered that not only digital literacies but also various cognitive and non-cognitive skills like teamwork discussion skills developed in the process.
Tapping LMS data: Student participation in "preparing-for-the-test" discussion forums

Dr Dorothy Langley, Holon Institute of Technology

Learning Management Systems (LMS) are widely used in contemporary higher education as platforms for pedagogical and administrative instruction management. When carefully designed, the LMS can model knowledge organization, appropriate style of communication and improved time management. The LMS can also be useful as a research tool, since it records activities within the course site and data can be extracted via system generated reports (Macfadyen, & Dawson, 2010).

The academic calendar contains stressful exam periods. Students are often confused and unsure of what exactly will be required. As students start preparing for the exam many questions arise, which they would like answered, preferably "instantly". This situation calls for devising an effective solution for publishing, documenting, sharing and answering questions, in an academically sustainable manner.

Over the past decade I have constructed "Preparing-for-the-Test" discussion forums in several course sites to help students prepare for assessment events. Seeking answers to the research question: What was the characteristic student participation in the Q&A discussion forums? I have used three data sources: The recorded discussion strings, data provided by the LMS records and students' response to a post-exam questionnaire. Sample data will be provided from the 2017-2018, 2nd year course with over 70 students, which had a mid-term and a final exam. The mid-term discussion forum showed 3 discussion strings, in which 3-4 students plus the lecturer participated. The final exam discussion forum showed 19 discussion strings, in which 12 students plus the lecturer participated. These data seem to indicate a rather low response level, which might act as evidence against the forum's usefulness. However, the issue of passive vs. active student participation in discussion forums is well documented (e.g. Rovai & Barnum, 2007). LMS collected data create a fuller participation profile, showing over 400 records of student activity in the mid-term forum, mostly involving "accessing" or "viewing" a discussion.

Over 2000 records of student activity, involving over 40 students were found in the final exam discussion forum. An interesting finding is that several students re-accessed the mid-term discussion forum in preparation for the final exam. The student activity chart (fig. 1) provides compelling visual evidence concerning the exam-related activity, showing peaks around exam weeks. The results of a questionnaire administered after the final exam shed more light on student views and participation in the relevant forums: 67% accessed and viewed questions and answers; 11% contributed questions; Usefulness was rated "high" or "medium" by about 60%. In conclusion, lecturers can create instructional impact by providing designated discussion forums in the LMS environment, serving students' needs at critical exam periods in the academic year. The advantages of the suggested forum extend beyond its obvious utility, and reside in the potential for promoting important students' abilities: formulating well-defined questions in appropriate academic style; creating Q&A repositories; becoming aware of peers' questions and trying to respond to them; self-checking comprehension of provided answers; when necessary, posing additional questions.
Interface, interaction and interactivity: understanding ImpaCT of technology in classroom from a Cultural Historical Activity Theory perspective.

Ibrahim Latheef, Monash University

Background and context

Information and communication input/output (ICIO) occur through the orchestration of technical interactivity and pedagogical interactivity. While technologies in classrooms support learning these elements are considered the key to successfully integrating technology in class (Beauchamp & Kennewell, 2013). Therefore, it is important to first understand what these elements are. Technical Interactivity in this context means the exchange of information and communication, among participants in the process of teaching and learning, that is facilitated by access to technology; in this case the IWB. There is a two-way flow between the technology and its users (Higgins, Beauchamp, & Miller, 2007; H. Smith, Higgins, Wall, & Miller, 2005). The presentation and touch features of the IWB provide a unique and enhanced technical interactivity environment that has not been previously possible with any other technology. Kennewell (2001) argues that it is not only the presentation and touch features of the IWB that should be considered when thinking about technical interactivity. There are further technical features of IWB systems, both at the hardware and software level, that add to the uniqueness of the environment and may provide distinctive learning opportunities. The other aspect of ICIO in a classroom is Pedagogical interactivity. In this context it means information and communications between teacher and learners, and learner and learners, to achieve educational goals (Higgins et al., 2007; H. Smith et al., 2005).

Pedagogical interactivity is assumed to be influenced by the technical interactivity if IWBs are part of the classroom as well as by the cultural historical influences on the teacher and the learners, including their cultural historical experiences with the technology. Syh-Jong Jang and Tsai (2012) have identified the literature on pedagogical approaches using IWBs and indicate the need to see the use of IWB as part of the teacher’s pedagogy. As Campbell and Martin (2010) argue, “while they [IWBs] provide a means of introducing new learning opportunities, the technology must be supported from a pedagogical perspective” (p. 74). Therefore, it is important to consider more than just their technical affordances, and also take into account learning goals, the views of the teacher on learning and knowledge, and the relationship between students, teachers and classroom settings. Cultural Historical Activity Theory framework and Sweeney (2008) stages were helpful in theorising ICIO and examine the impact of teaching and learning using IWBs.

Theoretical framework

Cultural Historical Activity Theory (CHAT) provides a descriptive framework in understanding classroom teaching and learning. The second generation activity triangle is most commonly used in research and provides an understanding of the classroom structure and the hierarchical structure of activity identifies the level of consciousness involved in teaching and learning episodes. Early generations of Cultural Historical Activity Theory research can be found
amongst human computer interaction (HCI) researchers (Bødker, 1996; Kaptelinin & Nardi, 2006; Kuutti, 1996; Nardi, 1996), where cultural and historical influences played a significant role in understanding IWBs, since the computer is an integral part of this technology. Following is how classroom activity is structured when IWB is used a technology.

![Activity System Diagram](image)

**Figure 1: Activity System**

Putting IWB use in teaching and learning into CHAT perspective emphasises the six tenets of the activity theory. In this model (Figure 1), the teacher (subject), learning goals (object), learning outcomes (outcome), learners and other staff (community), the IWB and language (material tools & conceptual tools), classroom rules and IWB instructional manual (rules), and the specific roles of the teacher, learners and other staff (division of labour) are the elements of a typical teaching and learning activity using IWBs (Figure 1). The relationship between subject and the objectives of the lesson is mediated by the use of the IWB and its potential; and its relationship to peers, teachers and other staff are mediated by rules; finally, the relationship between lesson objectives and peers, teachers and other staff is mediated through the roles they take up in the activity. Therefore, putting IWB into CHAT perspective, these relationships are orchestration of technical interactivity and pedagogical interactivity; thus, results in ICIO. Based on Leont’ev (1978) notion of hierarchical structure activity, these relationship as ICIO occur in three different levels,

Learning episodes consist of a three-tier hierarchical structure: activities, actions and operations as illustrated in Figure 2 (Leont’ev, 1978). This three-tier structure is explained thus: activity is an object-oriented and socially mediated process comprised of chain of actions, where actions are conscious, tool-mediated, and goal-oriented; whereas operations are routinized and therefore unconscious components of actions of a subject in response to concrete conditions. Operations are “the methods for accomplishing actions” (Leont'ev, 1978, p. 65). Leont'ev (1978) elaborated on this idea in his famous primeval collective hunt example. When an individual participates in a primeval collective hunt their role may be as a beater, and is to frighten animals and direct them towards other hunters, hiding in an ambush. This example illustrates that the division of labour supports the distinction between what motivates a person
(in this case, food) and to what the person’s actions are directed (in this case, making animals run away) and the conditions in which the person conducts their actions (Leont’ev, 1981). As previously discussed, classroom with IWBs consists of six tenets and the relationships between these tenets are mediated through ICIO occurs between them in three different levels as illustrated in the following figure 2.

![Figure 2: The hierarchical structure of activity](adopted from Kaptelinin & Nardi, 2012, p. 28)

As Figure 2 shows, there are three actions (actions 1, 2 & 3) that comprise the activity, where action is comprised of three operations (operations 2.1, 2.2 & 2.3). According to the IWB literature (see for example Kennewell & Beauchamp, 2007), there is more than one intrinsic and constructed feature comprising each possible pedagogical action, which is consistent with CHAT’s hierarchical structure. As discussed previously in relation to Leont’ev’s (1978) primal hunting example, this figure also represents the interrelationships of operations and conditions, actions and goals, and activity and motive (object). Therefore, these principles and concepts and Sweeney (2008) stages of Interactivity ideally support attempts to understand ICIO around IWBs.

A framework was developed by Sweeney (2008) which allowed to further understand technical and pedagogical interactivity in a classroom and how they are considered more effective. Sweeney (2008) framework identified interactivity as two distinctive sets of 5 stages of technical and pedagogical interactivity; however, this study has employed as one set of stages of interactivity. This framework suggest that it can be used as guidance to reflect on and develop teaching skills using IWBs’ affordances and constraints. The framework consists of five stages of ICIO as referred here. In this framework, Stage one is considered lowest level of ICIO and Stage five as highest ICIO. These stages were described as: Stage one “Whiteboard/Blackboard replacement” where the main focus was only on the technical features of IWBs, not using them to support the pedagogy. It was also identified that teachers are still getting used to the touch and the pen technology of IWBs. Stage Two “Support didactic” was when teachers begin to use the software that comes with the IWB. This was predominantly using the flipchart and teacher directed teaching. However, teachers start to provide opportunities for students to come in contact with the IWBs. The use of IWBs still remains mostly as a visual and organisational tool. Stage Three “Interactive” was when the teacher begins to move beyond replicating their old teaching style, to use the unique potential of IWBs. Stage found “Enhanced Interactive” was when teachers reach a high level of technical skill and there was an enhanced use of the IWB and high quality digital learning content was in use. Stage Five “Synergistic user” was when as described in literature as the highest level of interactive teaching and learning
(Beauchamp & Kennewell, 2013). Teachers and learners were using the IWBs without interruption and focus on achieving learning goals as if the technology were ‘invisible’. The teachers at this stage were confident and assume various technical and pedagogical techniques and mentor colleagues on best practices around IWBs. This framework neither identify level of ICIO nor any learning theory underpins it; however, was very useful in confirming the findings of this research in understanding the impact of the teaching and learning.

Table 1: Stages of technical interactivity

**Stage 1: Whiteboard Replacement**

<table>
<thead>
<tr>
<th>1.1</th>
<th>Predominant use of the interactive whiteboard for text and drawing or as a projection device.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2</td>
<td>Limited use of stored files (e.g. for Word files for spelling lists or grammar exercises).</td>
</tr>
<tr>
<td>1.3</td>
<td>Changes made to files and annotations rarely saved.</td>
</tr>
<tr>
<td>1.4</td>
<td>Teacher learning to use the pen to navigate files in place of mouse and use text recognition.</td>
</tr>
<tr>
<td>1.5</td>
<td>Predominant use of native interactive whiteboard software and perhaps one additional word processing program.</td>
</tr>
</tbody>
</table>

**Stage 2: Support Didactic**

<table>
<thead>
<tr>
<th>2.1</th>
<th>Predominant use of stored, original teacher created sequences of pages using native IWB software incorporating basic features (e.g. 'drag and drop' of words).</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2</td>
<td>Files are often prepared prior to lessons, 'Save as' is used after lessons so that word can be retrieved.</td>
</tr>
<tr>
<td>2.3</td>
<td>Limited use of external resources (e.g. Internet or school intranet).</td>
</tr>
<tr>
<td>2.4</td>
<td>Use of existing graphics (i.e. clip art) in the native IWB software standard library to 'decorate' work.</td>
</tr>
<tr>
<td>2.5</td>
<td>Incorporation of scanned images of textbook pages and worksheets.</td>
</tr>
</tbody>
</table>

**Stage 3: Interactive**

<table>
<thead>
<tr>
<th>3.1</th>
<th>Use of a wider range of tools and interactive whiteboard effects (e.g. random name generator, hide &amp; reveal, timer, magnifier, and mathematics tools).</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2</td>
<td>The ability to use tab browsing and minimise or maximise windows to switch between applications (e.g. native IWB software and browser).</td>
</tr>
<tr>
<td>3.3</td>
<td>The ability to use tab browsing and minimise or maximise windows to switch between applications (e.g. native IWB software and browser).</td>
</tr>
<tr>
<td>3.4</td>
<td>Native IWB software files are shared with others via Internet and/or Intranet.</td>
</tr>
<tr>
<td>3.5</td>
<td>Use of a wider range of graphics (including those from the Internet, digital camera and scanner) specifically chosen for purpose not just 'decoration'.</td>
</tr>
</tbody>
</table>

**Stage 4: Enhanced Interactive**

<table>
<thead>
<tr>
<th>4.1</th>
<th>Teachers are able to use a wide range of open-ended and subject specific software programs (beyond native IWB software) and online tools (e.g. to create concept maps, music, artwork, digital stories, audio files, blogs, personal portfolios and collect, manipulate and analyse data).</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2</td>
<td>Laptops are used to complement activities with the interactive whiteboard and there is experimentation with the use of other input devices controlled by students (e.g. wireless keyboard, slate, digital microscopes and data loggers).</td>
</tr>
<tr>
<td>4.3</td>
<td>Use of advanced features of native IWB software (e.g. text techniques using multiple layers, animated objects, Flash action buttons).</td>
</tr>
</tbody>
</table>
4.4 Teachers use online social networking software tools (e.g. del.icio.us) to manage and locate relevant websites.

Stage 5 Synergistic User

5.1 Teachers demonstrate a high level of skill and an intuitive interaction using a range of open-ended and/or subject specific applications and online resources and tools (e.g. graphing software to demonstrate manipulation of scale and use of wikis, podcasting and blogs).

5.2 Seamless incorporation of external input devices and software applications to enable synchronous sharing of students' work direct from laptops etc. onto the IWB.

5.3 Use of synchronous and asynchronous communication tools (e.g. video conferencing, instant messaging, audio comments, desktop sharing software and web based communication applications).

5.4 Storage and retrieval of lesson artifacts created by students from a network or online storage site with student and parent access from home (e.g. class blogs, wiki, SlideShare).

5.5 Use of 'record' to capture actions and dialogue using the interactive whiteboard to enable students to review work independently.

(from Sweeney, 2008, p. 29)

Table 2: Stages of pedagogical interactivity

Stage 1: Whiteboard replacement

1.1 The teacher designs lesson that do not rely on the interactive whiteboard and use it occasionally.

1.2 Only the teacher uses the interactive whiteboard.

1.3 Teacher presentation dominates over questioning.

1.4 More eye contact with class

1.5 Quicker pace to lessons

Stage 2: Support Didactic

2.1 The teacher structures student tactile interactivity with the board. Emphasis is on using the technical features to demonstrate understanding and maximum student participation (e.g. ‘drag’ content on the board as part of cloze procedure, or sequencing activities).

2.2 ‘Flip book’ pages are sequential and designed as templates or ‘digital worksheets’ where the whole class works on the same learning activity at the pace set by the teacher.

2.3 Used most commonly for teaching English and mathematics

2.4 Use of ICT ‘vocabulary’ by teacher and students when using the interactive whiteboard.

2.5 Teacher questioning follows the pattern of Initiate-Response-Feedback

2.6 The interactive whiteboard is primarily used to provide visual support for text-based teacher-directed instruction to the whole class.

2.7 The interactive whiteboard is used as a behavioural reward for students who complete their ‘other’ work and engage with class activities

2.8 Files are retrieved to review and extend previous learning.

Stage 3 Interactive

3.1 Teacher initiated and planned opportunities for student to select tools, and interact with the board to apply and analyse conceptual knowledge (e.g. students manipulate learning objects and mathematics tools, and play games).
3.2 Use of the interactive whiteboard to connect knowledge across Learning Areas, and connect students’ prior knowledge to the unknown.

3.3 Frequent and confident use of the internet to access interactive websites, locate information spontaneously when needed and to develop students’ information and critical literacy skills.

3.4 Retrieval of saved ‘flip charts’ by teacher to review and continue previous learning.

3.5 Teachers consciously plan and rely on the use of the interactive whiteboard to support specific learning outcomes and deep conceptual knowledge that can be easily achieved with it (e.g. using shared images, accessing online resources and manipulating geometry tools).

3.6 Teachers experiment with how to integrate the interactive whiteboard into relevant sections of planned lessons involving a blend of whole class and small group work (e.g. plan 4-part lesson comprising: Starter, Introduction, Development, and Plenary).

3.7 Increased pace of lesson to maintain student engagement using the interactive whiteboard as an organizational tool (e.g. use of hyperlinked resources, timer and moderate student tactile interaction with board).

3.8 Increased use of ‘flip charts’ created by others. Some of these are modified to suit specific learning contexts.

Stage 4 Enhance Interactive

4.1 Use of multiple forms of representation to support substantiative communication, demonstrate difficult to teach key concepts, and process in motion (e.g. analyse live online data and incorporate animation, video, 3-D modelling, simulation or dynamic data software and virtual worlds).

4.2 Use of a range of applications (beyond flip charts) to construct and apply conceptual understandings with students in meaningful ways using higher order thinking skills (e.g. create and analyse online survey data using SurveyMonkey™ and create authentic text such as event posters and electronic year books).

4.3 Students frequently and confidently use the interactive whiteboard as part of lessons stimulating sustaining dialogue between students and the teacher and between students.

4.4 Input devices are in the hands of students to demonstrate their understandings.

4.5 There are opportunities for students to demonstrate their inquiry based learning skills to an authentic audience using the interactive whiteboard (e.g. students present their personal digital projects to peer or assist the teacher to co-construct learning resources).

4.6 The interactive whiteboard is used to edit and annotate student’s works in progress in a supportive environment, generating sustained dialogue and feedback on learning (includes scanned book work and digital files).

4.7 Use of ‘flip charts’ to provide differentiated learning activities to cater for all students’ needs

4.8 Teachers collaborate in formal and self-organising ways to share resources and support each other to develop their technical skills, and pedagogical ideas for shared integrated units of work and lessons.

Stage 5 Synergistic User

45
Students determine many significant aspects of lessons either independent of, or dependent on, teacher approval (e.g. the direction, momentum and scale of the next step in the lesson).

The interactive whiteboard is an integral part of spontaneous, non-linear, fluid activities that support intended learning outcomes.

The available technology is deliberately used to support Assessment for, as and of learning (e.g. the teacher incorporates voting quizzes to assess progress design a range of intellectually challenging assessment tasks to cater for individual needs).

Teachers are able to articulate and apply their comprehensive knowledge of contemporary learning theories, strategies, various curriculum and planning frameworks and skills to provide an inclusive and differentiated curriculum for students. (E.g. projects based on an Inquiry approach or ‘Backwards by Design’ model involving essential questions, authentic tasks and assessment, collaborative problem solving, higher order thinking and Multiple Intelligences).

Teacher works collaboratively to plan, reuse and refine high quality comprehensive units of work. These units link a range of high quality resources, activities and assessment tasks to stimulate and support learning using the interactive whiteboard over extended periods. Emphasis is on the use of the interactive whiteboards to do new things in a new creative and innovative ways.

Use of synchronous and asynchronous communication tools to connect with other students or external experts globally on collaborative projects or to seek information and compare multiple perspectives.

Spontaneous use of the board to accumulate evidence of learning (e.g. use of the ‘camera’ or ‘record’ tools to capture learning moments as they occur for use in the plenary session).

(from Sweeney, 2008, p. 30)

The concepts and descriptions of Leont'ev (1978) and Sweeney (2008) were theorised to reach the following structure of the ICIO and understanding teaching that foster learning and its ImpaCT. The indicators and descriptors of the two frameworks were analysed for its common understanding and level of performance and activity that were enabled in each tier and stage. The lowest stage of interactivity in Sweeney (2008) were in line with “operations” as described in Leont’ev (1978). Similary, the level of interactivity as described in stages two and three of Sweeney (2008) were in line with Leont’ev (1978) “actions”. Finally, stages four and five of Sweeney (2008) were in line with Leont’ev (1978) top tier “activity”.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Stage1: Whiteboard/Blackboard replacement</td>
<td>Operations</td>
<td>Interface</td>
</tr>
<tr>
<td>Stage2: Support didactic &amp; Stage3: Interactive</td>
<td>Action</td>
<td>Interaction</td>
</tr>
<tr>
<td>Stage4: Enhanced Interactive &amp; Stage5: Synergistic user</td>
<td>Activity</td>
<td>Interactivity</td>
</tr>
</tbody>
</table>
Figure 3: The structure of ICIO

Interfaces is where the surface level of ICIO occurs. Interface, as theorised here, is based on the definition, “a device or program enabling a user to communicate with a computer, or for connecting with a computer, or for connecting two items of hardware or software” (T. Smith, 2000). Based on research findings, interface is mostly at the surface level of ICIO between the participants and the IWBs and other tenets of the activity system and was observed and recorded during data collection. Beauchamp and Kennewell (2010) have used the concept of ‘superficial interaction’ to explain this level of ICIO within learning episodes (p. 759). A lot of research on IWBs has been based on what was observed on the surface and critiqued for not including the contextual factors that structure learning (Liang, Huang, & Tsai, 2012). In CHAT terms, there are operation; however, become interfaces when they are automated and they are completed effortlessly, as observed and demonstrated in the videos of the data collected. As theories here based on Leont'ev (1978) and Sweeney (2008) the interfaces were interactions, ICIOs that requires a conscious effort to perform at first (Engeström, 1987; Jonassen & Rohrer-Murphy, 1999). In this research, the teachers and especially the learners, quickly became experts with these surface level ICIOs and became automated performances. Based on CHAT, the interface level of communications does not include consciousness; therefore, if the learning includes only interfaces there is less learning; as a result, it may leave a low impact on learners. The second level of ICIO as theorised and identified in this research are “interaction” and was used here as reciprocal actions and influences (T. Smith, 2000), and involves two or more people (Wang, 2004). It is also referred to as “tools in action” (Kumpulainen & Mutanen, 2000) and in this case the ‘actions’ were the participants using the IWBs as a tool to achieve learning goals. Maher (2012), who examines the dialogic nature of whole-class interaction, argues that interaction was important in supporting effective learning, and highlights the collective nature of interaction in achieving learning goals and in learners being able to express their own thinking more conspicuously. Furthermore, Liang et al. (2012) argue that interactions were reciprocal, as are confrontations and negotiations and the various strategies that confirm ideas. This suggest that interaction level of ICIO results in a higher impact learning compare to interface.

Interactivity is the deepest level of ICIO and highest impact level, resulting from combinations of interfaces and interactions sequenced to achieve learning objects (see Table 3). From a CHAT perspective, interactivity is a social process of mediating by tools, through interactions, to achieve learning (Leont'ev, 1978; Vygotsky, 1978). Beauchamp and Kennewell (2010) usefully define and draw on a distinction between interaction and interactivity for this research. They argue that ICTs, in this case IWBs, can be used as object, participant and tool. However, based on CHAT, when the object of the activity is learning, IWBs are best utilised as a tool only. The present study is concerned with IWBs as a tool and the object is to achieve the purpose of the learning episode. In other words, they are all different aspects of teaching and learning that are not distinctive but exist within levels of ICIO: interface, interaction and interactivity. Therefore, interactivity is achieved, drawing on Luckin (2008), when all the interactions are sequenced and orchestrated to provide a particular context based on the object of the learning episode, including the people, tools, rules and the roles these elements play. Table 3 demonstrates how interfaces constitute interactions and interactions are sequenced to achieve interactivity. Depending on how the interactivity and how interactions were sequenced and whether they consisted of appropriate interfaces, a high level of ICIO was achieved; thus, higher ImpaCT.
Methodology
This research employs a qualitative case study methodology. The rationale behind this embedded approach is that this study proposes to examine different settings – interactivity around IWBs in four different classrooms conducted by four different groups of teachers and learners. This is also justified on the basis that the unit of analysis includes four classes as sub-units, a further feature that is a characteristic of an embedded case study. Making analytic generalisations in this study is designed to further understand the concept and development of interactivity around IWBs, which in turn helps to understand other cases or situations (Robson, 2002).

Sample selection was made by inviting three schools with IWBs installed in their classroom in the metropolitan South-Eastern suburbs to achieve logistical advantage as the researcher was located in Monash University Peninsula campus. All of these schools were considered average performing based on The National Assessment Program – Literacy and Numeracy (NAPLAN). Data collection was carried out using classroom video, observations, interviews and planning documents. Four IWBs, four cases were examined in this study for their shape of interactivity, the level of technical interactivity and pedagogical interactivity. The key research question was “what shape of interactivity exist in each of the learning episodes” in each case. Video was the main source of data as it allowed to capture the different ICIO better than any other methods and one of the richest form of data collection in educatin research (Erickson, 2006). Altogether, the data set consisted of 20 videos/audios (classroom video of each lesson), 20 field notes (classroom observations of each lesson), 9 transcriptions (four teacher interviews, one administration staff interview and focus group chats) and 21 documents (planning documents for each of the 20 lessons and one IWB instruction manual). The data were managed and analysed using NVivo® data analysis software. NVivo® is a software package developed by QSR Interaction to analyse qualitative data (Creswell, 2009; QSR-International, 2013). Each case was then carefully constructed to to understand how each step of data collection, Six-Step framework informed the key research question as illustrated in figure 4. This allowed to create a story for each case from these varied sources of data and identify how ICIO based on activity and herarchical structure of activity impact classroom and participants’ effort towards achieving learning goal while depending on the potential of the IWB. Finally, using NVivo®, a set of themes were developed based on NVivo’s condensing, thematising and grouping of the CHAT frameworks, levels of ICIO indicators; technical interactivity and pedagogical interactivity and from the research questions.

CHAT based Six-Step framework (Latheef, 2016) provided a guideline to collect and analyse the qualitative data. The framework included a process that created a comprehensive and very rich description of the classroom teaching and learning as an activity system as outlined in Figure 1. The Six-Step framework includes:

- Step one – understanding the activity and the setting – seeks to understand the activity and setting by clarifying the intention of the subject and the object of the learning episode
- Step two – analyse actors of the activity system – seeks to analyse the actors of the learning episodes.
- Step three – analyse the mediators of the activity system – analyses the mediators of the learning episode.
- Step four – analyse the structure of the activity system – is to analyse the structure of the activity system. This is important in order to identify interactivity around IWBs.
• Step five – the context – attempts to understand the context in which teaching and learning occurs. The purpose of this step is to find out what the cultural and historical influences are on the participants and the classroom setting in which they perform.
• Step six – analyse the outcome and the activity system dynamics – involves analysing the outcome of the learning episodes.

**Figure 4: Data Analysis process**
Adopted from (Latheef, 2016)

**Findings**
As previously discussed theoretical understating (see Figure 3), level of ICIO and its impact on learning involves interactivity as the highest level of ICIO and impact, interaction as second level and interface as most superficial and lowest level of ICIO and impact. Since the term ‘ICIO’ is used to describe the reciprocal relation between the tenets (Figure 1) of the activity system (also see Figure 3), Figure 5 illustrates an example of levels of ICIO when IWB was used in teaching and learning.
Figure 5: example of structure of ICIO
Adopted from (Latheef, 2016)

In this sample episode, the highest level of ICIO is when learning sounds and letters and reading using IWBs, which ultimately achieved as learning goals. This is the highest level of impact according to the findings and achieve more learning and hence a greater impact on learners. At this level, the learners were involved in “meta-cognitive practices”, and they were “constructing meaning and understanding in order to expand their view” of the learning materials and goals (Sweeney, 2013, p. 222). If the learners were just performing at the interaction level, where they may be engaging in some questioning, prompting, responding, comparing, listening, readings, referencing, identifying and watching; however, may not achieve the learning goal through interactivity if they are not carefully orchestrated. In many instances during the learning episodes in this research, the same interfaces were used in two different learning episodes and achieved a different interaction, which indicated expert orchestration in order to achieve interactivity (Beauchamp & Kennewell, 2010). These were, in turn, the result of using the following operations: inking, touch/click, match, select/choose, roll and play. It is important to note that interfaces and interactions were used in multiple instances, even within the same learning episode, and their sequence can be altered to suit the teachers learning goal. Together, this three-tiered structure describes the interrelationship of all conscious and unconscious thinking and performance focused on the learning episode’s learning goals, interactions, and the nature of the observed behaviour (interfaces).

Conclusion

The higher the ICIO, the greater the learning and the impact on learners. This was evident in this research based on the findings and as CHAT argued that where there are more conscious actions there are more learning. From the learning episodes, it was clear that a higher level of impact was at the higher level of ICIO – interactivity. This research has identified interface, interaction and interactivity within the elements of the classroom teaching and learning system and deeper understanding consequently led to more engagement and productivity. Findings concluded that episodes and that were categorised as having a higher level of ICIO, more
interactivity, was also ranked highest in framework by Sweeney (2008) and Leont’ev (1978). Therefore, this confirms that a higher level of ICIO leads to more learning and a greater impact on the learners.
References


The scope of online learning in K-12 education is developing and changing as more effective digital tools in conjunction with new pedagogies emerge. The ability to learn online is enabled by faster Internet speeds and better access to online spaces as well as new ways of working that allow participants to connect and collaborate virtually in order to build knowledge together. This research is based on the theoretical framework of connected and collaborative learning in an online context. Connected learning makes use of new technology tools to build online networks and develop personal learning resources through interaction with personal learning networks and professional learning communities (Siemens, 2005). Connectivism is a term describing practice based on the idea that knowledge is distributed across networks of connections and that learning consists of the ability to construct and traverse those networks (Downes, 2008). The ‘ecology’ of connected learning and connectivism relates to diverse, multifaceted learning spaces where specific tasks are aligned with the unique nature of different learning approaches (Siemens, 2006).

In the collaborative learning process, as distinct from cooperative learning where the required tasks are distributed amongst the learners (Laurillard, 2009), the affordances of online technologies allow learners to share, discuss and build on the outputs of their peers or collaborative partners. The social nature of learning and online collaboration may lead to the development of a ‘Community of Practice’ or CoP, a group of networked learners who share a craft and/or a profession (E Wenger, 2000) and experiences are shaped by the many as opposed to the individual teacher (E Wenger, White & Smith, 2009). Lock and Johnson (2017) consider knowledge building is continuous when collaboration is implemented as a way of learning. Harasim (2012) suggested that online collaborative learning (OCL) applications afford an emphasis on knowledge work, knowledge creation and knowledge community.

What is online global collaboration?

In practical terms, Lindsay (2016) defines online global collaboration in the K-12 classroom to mean learners who are geographically dispersed who use online technologies to forge viable connection and communication leading to collaboration and co-creation of new understandings. This means learning in a global context is ‘with’ not just ‘about’. According to Garrison and Cleveland-Innes (2005), key factors are the use of online technologies and design features of the collaboration, as well as changes made in teaching and learning structures for all collaborative partners involved. Lock (2015) discusses the global classroom and focuses on the importance of learning design scaffolded by online technologies to support authentic collaboration.

Why is online global collaboration important?

Online global collaboration is important to prepare all learners to be globally competent, where global competence is defined as the “cross-cultural skills and understanding needed to communicate outside one’s environment and to act on issues of local and global significance” (Lindsay, 2016, p. 242). Connecting beyond the classroom “supports global citizenship and
competency because it allows students to frame an understanding of the world through connected experiences beyond the typical textbook and limitations of face-to-face interactions” (Lindsay, 2016, p. 22). Paterson (2016) advises that developing “global competence is not about adding a new unit to the curriculum but about seeing teaching practice through a new lens” (p. 199).

Online global collaboration provides opportunities for students to actively engage with digital technologies while connecting with others. The ability to connect beyond the classroom builds skills around the use of new or emerging tools for online and ubiquitous computing. As students engage in online collaborations, they gain an understanding of the power of technology to benefit humanity. Bates (2016) identifies ‘digital skills’ as requisite in a digital society but warns that the “use of digital technology needs to be integrated with and evaluated through the knowledge-base of the subject area” (p. 19). Veletsianos (2016) posits that by employing emerging technologies to support learning, new ways of viewing the world have become apparent as are new “ways of exploring knowledge, scholarship, collaboration, and even education itself” (p. 11).

Changes in teaching and learning beyond the classroom are supported by pedagogies that challenge isolation, and online global collaboration is vital to create a new paradigm for modern learning. Learners must be able to go beyond the textbook in order to connect, not just with current content, but also with people - peers, experts, and online communities - whose collective voice helps students build a deeper understanding of the world. The paradigm shift to include online collaboration as a norm is shared by Lee and Ward (2013) who state that “while insular, ‘stand alone’ teaching has characterized the teaching of a paper-based world, collaborative teaching could well characterize that of an increasingly digital and networked world; a world where collaboration and integration are the norm” (p. 3).

Online global collaboration supports the concept and practice of ‘glocalisation’, a blended word from ‘global’ and local’ originating in the early 1990’s and referring to accepting differences while applying to the local context without homogenisation (Robertson, 1995). Friedman (2007) states, “The more you have a culture that naturally glocalizes - that is, the more your culture easily absorbs foreign ideas and global best practices and melds those with its own traditions - the greater advantage you will have in a flat world” (p. 422). The goal is not for one culture to emerge but to find differences as well as commonalities. Tagüeña (2008) states that, “A glocal approach means presenting global knowledge within a local context that respects human rights. It encapsulates the concept ‘think globally, act locally’.”

**Online global collaboration in K-12 learning**

Research on K-12 educators engaged in telecollaborative projects through the International Education and Resource Network (iEARN, http://iearn.org) (Oran, 2011) showed that they framed a conceptualization of global education around their own experiences and values and around students’ needs and experiences. Although educators lacked formal preparation for global learning they integrated global education into their classrooms because of their personal commitment to it, and in spite of a lack of formal curriculum. The study by Leppisaari and Lee (2012) of elementary level students connecting between two countries showed how the use of technology for collaboration can be strengthened in meaningful ways and identified pedagogic models based more on what did not work. They observed that challenges to online global
collaboration included varying conditions that exist in respective schools, systems and
countries; cultural differences impacting communication styles; interruptions in the timeline
affecting completion of agreed outcomes and the attitudes and habits individual educators have
that can make collaboration a success or not. When social studies classrooms were joined
globally Lock (2017) found “[t]he affordance of digital technology opens a new learning
landscape that offers new possibilities for how we engage students in authentic learning
experiences” (p. 26).

The Australian Curriculum includes general capabilities which are knowledge, skills,
behaviours and dispositions that students are expected to develop during their schooling. One
of the capabilities is to “develop intercultural understanding as they learn to value their own
cultures, languages and beliefs, and those of others” (‘Intercultural understanding’, 2018). This
is part of an international focus on K-12 curriculum outcomes requiring a commitment to the
concepts of global learning, collaborative learning and learning with and through ICTs. For
example, in the USA the ISTE standards (2016) for students include ‘Global collaboration’ as
one of the key elements, where “Students use digital tools to broaden their perspectives and
enrich their learning by collaborating with others and working effectively in teams locally and
globally”.

**Research method**

The purpose of this qualitative research was to document and analyse the experiences of
educators who had implemented online global collaboration in the classroom and to identify
emerging pedagogies influencing these experiences. After university ethics approval (University of Southern Queensland, approval # H15REA156, and a rigorous design process
of filtering potential interviewees through an initial online survey, K-12 educators (n=8) from
six different countries were invited to share their online global collaborative experiences in a
one-hour semi-structured interview. Five of the eight interviewees were 50 years of age or older
and had taught for more than 25 years. Teaching areas included elementary classrooms, library
and ICT specialists, as well as high school subject specialists such as Business Studies and
World Studies. Further details of the interviewee profiles are shown in Table 1.

<p>| Table 1: Profile of Interviewees for Phase 2: Semi-Structured Interviews (n=8) |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| <strong>Pseudonym</strong>                   | <strong>Age</strong>         | <strong>School Type</strong>  | <strong>Location</strong>    | <strong>Grade levels / Subject area / Specialisation</strong> | <strong>Length of time teaching</strong> | <strong>Evidence of participating in or planning to participate in a global project of Level 2, 3, 4, 5 as per the Taxonomy for Global Connection</strong> |
| Stella                          | 60+             | Government      | Rural, Australia| K-12 influence, Mainly                              | 30+ years                    | China Connects <a href="http://www.connectchinacollaborative.com/">http://www.connectchinacollaborative.com/</a> |</p>
<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>Location</th>
<th>Position</th>
<th>Years</th>
<th>Project(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Janice</td>
<td>40-49</td>
<td>International</td>
<td>Thailan d (USA)</td>
<td>16-20 years</td>
<td>The Global Read Aloud <a href="http://theglobalreadaloud.com/">http://theglobalreadaloud.com/</a></td>
</tr>
<tr>
<td>Donna</td>
<td>40-49</td>
<td>Government</td>
<td>Urban, USA</td>
<td>16-20 years</td>
<td>Flat Connections Global Project <a href="http://flatconnectionsglobalproject.net">http://flatconnectionsglobalproject.net</a></td>
</tr>
<tr>
<td>Jill</td>
<td>60+</td>
<td>Government</td>
<td>Urban, Australia</td>
<td>30+ years</td>
<td>Persuasive Writing <a href="#">No URL</a></td>
</tr>
</tbody>
</table>
| Meredith | 20-29| Government        | Canada                          | 6-10 years  | Kids Who Code project [http://mrsobachsclass.blogs pot.com](http://mrsobachsclass.blogs pot.com)  
Flat Matt project - [http://adventuresofmatthew andjim.blogspot.ie/](http://adventuresofmatthew andjim.blogspot.ie/)  
Global Read Aloud - [http://www.globalreadaloud .com/](http://www.globalreadaloud .com/) |
| Angela   | 50-59| Independent       | New Zealand                     | 30+ years  | Flat Connections ‘A Week in the Life’ [http://aweekinthelife17-1.wikispaces.com/](http://aweekinthelife17-1.wikispaces.com/) |
The K-12 educators selected for the study had implemented, or were about to implement, an extended online global collaboration that was continuous for at least six weeks. The lens for this information was educator self-analysis of practice based on the Taxonomy for Global Connection (Lindsay & Davis, 2012). The ‘six weeks’ criterion was chosen as a significant and relevant amount of time with which to build a collaborative relationship with one or more classrooms at a distance and possibly co-create learning outcomes. Typical examples of online global collaborative projects include The Global Read Aloud (6 weeks in length, see https://theglobalreadaloud.com/) and iEARN Learning Circles (8+ weeks, see http://www.globallearningcircles.org/).

The following three research questions were used to frame the study:

1. What are the experiences of educators who implement online global collaboration?
2. How do educators’ beliefs about learning and teaching influence their engagement in online global collaboration?
3. In what ways do educators’ personal pedagogies enable online global collaboration?

A single-case design with embedded multiple units of analysis was chosen for this research (Yin, 2014). The context was K-12 education, the case was the phenomenon of online global collaboration, and the multiple units of analysis were individual educators. The focus of this case study was the lived experiences of educators as they used technology to implement an online experience that was both global and collaborative.

Transcripts of the audio recordings from the interviews were initially analysed through an inductive process, with common themes and categories identified and colour-coded using an open coding method (Corbin & Strauss, 2008). As an extension to this analysis, and based on the interview coding work of DeCuir-Gunby, Marshall & McCulloch (2011) and coding schedule structure of Hay (2017), a complete set of themes called the ‘Coding Playbook’ was determined. This Playbook organised the codes into three broad areas - educator experiences, educator beliefs, and educator pedagogical approaches. All interview transcripts were then coded into QSR NVivo 8 qualitative data analysis software using the final version of the Playbook as part of a second phase of analysis.

Note. Location in brackets refers to home country.
Preliminary findings and discussion

Preliminary findings and discussion presented in this paper are based on the experiences and perceptions of the eight interviewees. The first research question sought to explore the experiences of educators who implement online global collaboration. While their experiences were diverse, commonalities included overcoming barriers to online collaboration, finding ways to connect meaningfully with the world, using Web 2.0 technologies (such as blogs, wikis, other largely freely available online tools such as Padlet) for synchronous and asynchronous collaboration, and encouraging others within and beyond their school to participate. Online global collaboration motivates students to learn about different people and places, as illustrated by Stella (an ICT specialist working with Year K-12 students):

*I like to work with other people around the world...my students learn from them, rather than reading textbooks or looking things up online that might help them, and I find that they’re quite happy once they’ve connected with people and collaborated with them to go and research online a little more about the area where those people come from.*

All educators interviewed had adequate bandwidth and access to digital devices to be able to learn and collaborate online. Many indicated how the school situation had improved in recent times, with increased bandwidth and better access to mobile technologies, which (although not essential) did further support collaborative learning objectives. Comments such as, “So I feel it’s very open, comfortable and supportive in that way where I currently work” (Donna, high school World Studies teacher), and “We do have access, nothing much is blocked in our school, Facebook is still blocked at the Principal’s request but if we need a site we simply ask our technicians and it will be unblocked” (Stella), illustrate access and support within two of the school contexts. In comparison, one elementary teacher of Year 3 students (Janice) struggled with a lack of autonomy in the classroom and needing to seek permission to implement connected and collaborative learning activities (which were often denied). Janice sometimes experienced conflict within the administration of her school regarding permission to proceed with projects, with the IT Director saying ‘Yes’, and the Principal saying ‘No’.

The second research question investigated learning outcomes related to the implementation of online global collaboration. Participants identified enablers and tangible outcomes of implementing online global collaboration in the classroom. Situational enablers or precursors (determined by the school scenario) included access to Web 2.0 and online collaborative tools and a supportive administration. Personal enablers included having a personal interest in online collaboration, a disposition towards connecting beyond the classroom the capacity to use a range of technologies, and teacher experience leading to new pedagogical abilities.

Benefits or positive outcomes of online global collaboration for students included enhanced communication skills and support for ESL students, as described by Janice:

*Even Skyping, Skyping with another class or Skyping with an expert where they have to ask a question. I find that it is a really outstanding, motivating way to have students practise their English. And if they are native English speakers it is really good for them to practise their communication.*
Increased student motivation was also identified as a benefit of global online collaboration, as observed by Angela (an ICT specialist teacher of Year 6-8 students), “Students are much more motivated to read, much more motivated to write, much more motivated to co-construct in preparation for working with the other kids around the world.” These teachers found that an increase in students’ motivation led to higher engagement and less disruptive behaviour, as described by Janice, “My personal opinion is that it enhances student engagement and when students are engaged the learning is amplified”. It also contributed to student empowerment, as experienced by Meredith (a Year 1 classroom teacher):

... empowerment is the big piece of it because kids realise that the kinds of projects we do often involve tackling a problem or making a difference somehow so I think the empowerment piece is a big one since my learners are so young that they realise that their actions do have an impact and effect and can reach not only within their own class or school but to another country or another province or another city.

These educators also observed how their students developed an enhanced awareness of self and one’s place in the world, as well as a deeper knowledge of culture and country, leading to decreased ethnocentricty and a capability to build empathy with others. This is supported by Union and Green’s (2013) findings on the impact of global projects on overcoming ethnocentrism, where they found that “Web 2.0 technology helped, to a measurable extent, to impede student ethnocentrism and promoted positive working relationships that were related to student ethnocentrism during the global collaborations that were investigated” (p. 122). This is reinforced by Stella’s observation, “I think when we collaborate globally we learn just as much about those other people as we do about ourselves and I think our own personal sense of being an Australian etc. is terribly important as well.”

The third research question examined educator personal pedagogical approaches and how these are influenced by as well as support, extend and add value to online global collaboration. This will be discussed in the next section.

**Pedagogical approaches to online collaborative learning**

Current pedagogical practice of educators in this research in terms of dispositions and practice in the classroom is shown in Figure 1. They shared a variety of perspectives regarding educational philosophy, online learning modes, and approaches to sharing learning artefacts online. Some expressed a constructivist and inquiry-based approach as being fundamental to learning in the classroom. Not all were active on social media or maintained a personal or classroom blog (primarily through personal choice); however, they were all actively connecting, networking and learning with other educators online. Learning alongside students while also modelling and monitoring online behaviour and approaches was shared by most of the educators as an important approach. Pedagogical independence and curriculum agility, where educators could respond to change and flexibly change plans or modify the use of digital tools to support online global collaboration, were also identified as important. Furthermore, a culture of global learning within a school was seen as facilitating curriculum agility amidst a world where information is everywhere and knowledge can be co-created through collaboration. These practices provide a bridge to online collaborative learning that embraces global opportunities
Online global collaborative learning - pedagogy or curriculum?

When asked whether they thought online global collaboration was pedagogical or a curriculum approach, interviewees provided a range of responses, including:

It’s another way of learning, it’s another way of learning with people who are not right next to you but who have a different perspective who have different things to offer (Lindy, Year 5 classroom teacher);

You’re changing the way teachers are really teaching and students are really learning by how you’re doing your global project and project-based learning. (Valerie, Librarian and ICT specialist);

I think the pedagogy’s there and I think the curriculum now needs to be developed (Stella);

It’s more than a pedagogy, but I wouldn’t necessarily call it a curriculum. I think global collaboration for me is a necessity for us to teach children the skills they need for the 21st century, like in my opinion it should be a non-negotiable (Janice).

Donna articulated online global collaboration as a ‘philosophy’ of teaching and learning:

It’s a piece of the philosophy because if we are really teaching students to be global citizens or helping them become these global citizens how do you do that without having a global experience and understanding what that really means. So, it becomes a philosophy, a way of doing business and then it becomes part of everyday teaching and learning.

Emerging pedagogical practices for online global collaboration.
According to Lock (2015) a pedagogical shift is needed to move from a transmission-style approach to teaching to ongoing sustained conversations and collaborations for meaningful learning to occur within a global classroom environment. This research has shown the impact or influence of global collaborative skills leads to consolidation of new pedagogical practices that include learning while connected beyond the classroom, collaborative and open learning modes and community interaction. Implementing online global collaborative learning through both synchronous and asynchronous learning modes including online global projects provides the bridge to new pedagogical approaches. This ‘bridge’ includes real-world learning that was beyond the textbook, flexible and autonomous learning, having an authentic audience, approaches to global digital citizenship, and a focus on the process as well as the outcomes of global learning.

As an outcome of this research, an emerging pedagogical approach to teaching and learning is proposed, for now called Online Global Collaborative Learning (OGCL). When implementing online global collaboration with this pedagogical approach the concept and practice of ‘flat’ learning is adopted whereby an ‘unflat,’ (non-networked, hierarchical) non-collaborative learning environment is disconnected and isolated. The terms ‘flat’ and ‘unflat’ relate to concepts by Friedman (2007) where he discusses how digital technology has brought us closer together and we do not have to go “around” the world anymore; connections are flat; collaborations are flat. The ‘connected’ or ‘networked’ student (Drexler, 2010) is still a very new concept to students (and teachers). According to Donna, students find online virtual learning with others uncomfortable at first - they are not familiar with some of the tools and communication expectations, as she stated:

*It’s not the kind of setting they are accustomed to. They’re really used to interacting with their peer group, the people they know. When you ask them to do it in a, like I said, a professional or academic setting with people they’ve never met before, probably never meet face-to-face, all of a sudden that’s just a new concept for them.*

In conjunction with Donna’s statement Angela shared, “I can see them [students] trying desperately to make connections with the children around the world ... they want to get on and talk to each other.” Stella encourages her high school students to build their own networks and leverage them for learning; “They can ask their network questions in order to be able to do whatever they need to do within the classroom as well.” Donna cannot imagine a classroom where students do not communicate with others online, stating, “The dynamics of teaching and learning don’t quite feel complete or necessarily appropriate unless students are allowed to have those experiences.” She said her students also share with her how they feel disconnected in other classrooms where online connections and global projects are not embedded; they miss the dynamics of that connected classroom environment.

OGCL includes a pedagogical approach to open learning and the creation of an online learning legacy whereby learning is available for others to interact with, usually through the use of tools that support open yet scaffolded interactions and collaborations. These interactions extend learning into the community with development of new partnerships. This is distinct from online collaborative learning (OCL) (Harasim, 2012), or ‘Collaborativism’, the more recent term used by Harasim (2017). Whereas Harasim’s Collaborativism learning theory is based on peer discourse and the teacher acting as a representative and a gateway to the knowledge community within a particular discipline, OGCL is based on connection, interaction and collaboration with
peers, experts and other community members as part of the learning process. In OGCL the teacher has equal responsibility along with the student to forge online collaborative learning relationships and to self-direct where possible, this learning.

As Donna shared her students preferred to share their work only with the people they knew “When you put them out into an environment where you have them... peers and other teachers seeing their work that they've never met before that they're unfamiliar with, it's incredibly uncomfortable for them.” The benefits of virtually connecting and sharing work online as described by the interviewees included ‘motivating’, ‘drive to do a good job’, ‘engaging’, ‘wanting to do a better job’. Contradictory in terms of collaborative learning, however, is evidence where students wanted to show a ‘finished’ piece of work rather than approaching it as a collaborative effort. Angela stated, “Online global collaboration needs to be part of the learning, not on top of the learning” and referred to a recent collaboration where students at her school were writing and storing project outcomes in the usual Google apps location for the school rather than in the collaborative space.

They still need to make that shift that allows them to put things online in public before they are finished - to be able to share process and formative work. Angela says:

So what if it’s wrong, still put it out there and together we will get this proofed and read and looking good before the end when it all needs to be together rather than everything has to be perfect before we put it online ... that’s probably the big step that they still have to make.”

A broader concept of an online global collaborative framework is shared in Figure 2. This is directly related to the impact of online global collaboration. It also explains how OGCL fits into the overall learning scenario where global education, collaboration, and online learning are elements that can be blended. The left hand side of Figure 2 shows how collaborative learning, when joined with online learning, becomes online collaborative learning (OCL) (Harasim, 2012). At this point OCL can be, and usually is, entirely localised and within the one classroom, or perhaps within the one school or school system. This particularly applies to a school Learning Management System (LMS) whereby online collaboration is possible within but external partners cannot be added, and students from within cannot break through to share and connect with others beyond.
The right hand side flow of Figure 2 shows how global learning is initially practiced in isolation from online learning. Once global learning is joined with online learning, this then provides the opportunity for online global learning such as exploring the world through online resources and possibly reaching out to external experts and organizations for updated information. Finally, when online collaborative learning and online global learning are joined or merged this produces online global collaborative learning (OGCL). This is where learning is online, with others beyond the immediate classroom, ubiquitous, autonomous and open. Connecting with the world for meaningful learning provides freedom to not only find out answers immediately but to collaborate and co-create knowledge. Both Stella and Valerie referred to this approach to learning as ‘beyond the textbook’ learning.

The key to understanding this flow and development is through the concepts of ‘learn with’ and ‘learn about’. The global learning strand (right hand side) shows learning development that is typically ‘about’ - learning about the world offline, leading to learning about the world in an online capacity. The collaborative learning strand (left hand side) shows learning development that is typically ‘with’ – learning with others offline, leading to learning with others virtually, first locally and then globally, which then leads to collaborative learning, and virtual co-creation.

**Online global collaborative learning - implications for K-12 education**

In the new online global collaborative ecology online digital technologies are used to support relationships and social practices (Brown, 1999; Greenhow, Robelia, Hughes, 2009), and the context of learning in online spaces (Siemens, 2006) is self-motivated and autonomous. Lock (2017) suggests five guidelines for facilitating learning in a global classroom which include an intentional design of the learning, purposeful selection of technologies, responsive facilitation of the learning and online collaborative skills that support learners and co-created outcomes. Within the OGCL ecology skills, attitudes and norms of behaviour for implementing online
collaborative learning, both local and global, can be built. This then leads to learning where co-creation of products and understandings between participants/collaborators can occur beyond the same time and beyond the same physical space.

The educators interviewed for this study have taken a more ‘organic’ approach to learning the skills required for global collaboration. The following quote from Stella illustrates this: 
*I relied on learning with the people I collaborated with, and I think it’s by hands on and experiencing that, that you really learn very much about collaboration on a global scale.*

Donna believes participating in online global collaboration in the classroom has built her confidence to turn classroom behaviours into teachable moments, as she said, 
Thinking outside of the box, taking a risk, trying new things, and encouraging teachers to do the same so really working beside you, allowing you to take those risks, allowing you to fail and saying that’s ok, and those kind of supports are key.

Stella also shared, “It’s just a long slow journey Julie and as we all start I am sure it will keep building as people see more of the magic of it all.”

These educators were willing to take risks and demonstrated an evolving attitude towards ‘failure’ in the classroom. They were comfortable about being ‘different’ from other educators, even outliers within their school in order to implement OGCL. They had high expectations of connecting their students with others, and of communicating and collaborating virtually as part of their everyday learning. To not do so, felt ‘disconnected’. Curriculum flexibility and agility in the classroom were central to the process of learning, with the capacity to go beyond textbook learning. Implementing an online global project is a new approach to curriculum design, that is interdisciplinary, and provides for a new connectedness and collegiality.

The OGCL pedagogical approach has significant implications for K-12 education in that providing support and access for all educators will require a planned approach with consideration as to technology infrastructure, curriculum flexibility, assessment requirements, networked and connected learning and online learning capability.

**Conclusion**

Online global collaboration is still very new in schools. The educators in this study were able to take advantage of enablers and overcome both personal and situational barriers, to forge new and meaningful learning opportunities for themselves and their students. Outcomes of educator practice shared here align with international expectations for global learning and ICT supported skill development for collaboration. Pertinent to all educators’ experiences was the disposition to mutually create and learn from a global network. Relative isolation within the school as a global educator led to increased motivation to connect globally to share ideas and find support for collaboration. Curriculum flexibility and agility provided a bridge to further online collaborative experiences. New pedagogical approaches influenced by global collaborative activity have emerged that ‘flatten’ the learning experience. The findings of the study presented in this paper highlight the need for adequate infrastructure, curriculum development, teacher professional learning, and a clear understanding of OGCL and commitment to implement OGCL in meaningful ways.
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Self-impact & My-Impact: Teacher professional learning through social media
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Introduction
There is a gap in the professional development literature examining the difference between teacher professional development (PD) and teacher professional learning (PL). These terms are used interchangeably. With the permeation of the internet and the germination of social networking sites that are easily accessible, what we have traditionally considered professional development cannot define professional learning online. How teachers action their own professional learning needs and what is valued as professional development currently requires investigation and clarification.

The shape and form of professional development is evolving as teachers are seeking more than a one size fits all model often provided by their school. Additionally, teachers who are experts in their field are not supported by generalised professional development activities that are grounded in school based agendas. Conversely, how teachers conceptualise their professional learning and their role as part of it has a great impact on how they seek out activity online and in ‘traditional’ forms of learning as well as how they purposely engage. More is currently known about how teachers are engaging in traditional forms of professional development activities and the design of various types of activities available to teachers either based in schools, districts, nationally or indeed online. Less is known about how teachers conceptualise their own self-directed professional learning online that is based in professional learning networks with no course structure or environment. This study focuses on understanding the latter as contemporary approaches of teachers who are expert at integrating digital technologies- ICT expert teachers. How do these teachers action to learn for self-interest and does this learning impact themselves ‘Self-impact’ and or those they learn with ‘My Impact’.

Review of Literature

ICT Integration: the trend of formal professional development approach

Digital proliferation has ensured that integration of ICT is unavoidable placing greater requirements on professional development worldwide. Advanced and developing countries place significant value on the effectiveness and impact of professional development (UNESCO Institute, 2017). With a changing landscape of learning and measures of quality and impact complex (Kennedy, 2015), professional development is moving through a reformation period. Additionally, ICT professional development faces challenges associated with supportive school culture and school leader (Phelps, Graham, & Watts, 2011); teachers attitude and beliefs in relation to ICT (Prestridge, 2017; Judson, 2006), tensions between confidence and competence in using emerging technologies (Prestridge, 2012; Kettunen, Sampson, & Vuorinen, 2014) and even the number of ageing population of teachers who did not receive
training on ICT in their pre-service education and have lack of confidence and skills in integrating ICT in their class (Lundin, 2002).

In many schools, professional development for the integration of ICT has been approached diversely. It ranges from regular, formal training opportunities to more incidental assistance. Some schools have short courses, afternoon tutorial, IT demonstration in staff meeting, encourage university or postgraduate courses, peer support and incidental learning, but Phelps et al. (2011) found that none of these make significant impact on teachers’ outcome. Engagement of teachers in formalised school based professional development is considered as traditional professional development since it is based on the assumption that “teachers need direct instruction about how to improve their skills and master new strategies” (Lieberman & Miller, 2014, p.7). It is characterized as externally structured (Stevenson, Hedberg, O’Sullivan & Cathie, 2016), guided by outside-school expert (Trust, Krutka, & Carpenter, 2016), more content knowledge focused (Chen & McCray, 2012) in non-participatory type of learning environments (Brooks & Gibson, 2012). Teachers are not involved in constructing their learning (McCray, 2016) and are passive receivers (McLaughlin, 1994). Consequently professional development very often results in gaps between aims and what teacher needs (Evans, Tate, Navarro, & Nicolls, 2009; Ashadi, 2010; Opfer & Pedder, 2011), lack of enactment (Kennedy, 2016) or why teachers may value certain practices after professional development engagement but do not implement them (Easton, 2008; Opfer & Pedder, 2011; Gulumhussein, 2013; Cho, 2014). From the evaluation of the effectiveness of professional development, there is a growing understanding that formal teacher professional development often fails to be effective (Trust et al., 2016).

The trend of attending formal professional development is also investigated by Lipowski, Jorde, Prenzel, & Seidel (2011) through the views of experts from 5 European countries, i.e., UK, Norway, Denmark, Germany and Hungary. These experts view that there are typically single day professional development events in these European countries with no long term follow up which they maintain is required to support teachers’ learning. In addition, formal professional development that is external either in design or location is culturalised and well accepted as the norm for teacher learning (Bell, 2013; Lipowski, et al 2011; Svendsen, 2016).

The emergence of the term Professional Learning

Scholars have recently distinguished the term professional learning from traditional professional development as it is “broader, more critically reflective and less performative oriented” (O’Brien & Jones, 2014, p. 684) and based on a self-determinate agenda, which is considered to have capacity to involve changes in professional knowledge, attitudes, beliefs and or mindsets (Prestridge & Main, 2018; Stevenson et al., 2016). Although in some literatures, the two concepts are used interchangeably, the ideology behind the concept of professional development and professional learning is different and ‘that difference matters’ (Nilsson, 2012, p. 238). Pointing out the difference is seen as essential as “the replacement of one term with another is not helpful because it undermines the difference in meaning that the language is supposed to imply (Loughran, 2010, p. 200).

Professional learning emphasizes more than an externally designed intervention (Richter, Konter, Klusma, Lüdtke, & Baumart, 2014). It offers the meaning that the learning occurs ‘with’ and ‘by’ the teachers instead of ‘to’ or ‘for’ the teachers (Nilsson, 2012, p. 239). It
positions teachers with a more active role (Easton, 2008), as pedagogical experts who engage in the pursuit of genuine problems over time with a broader professional community. It is informal and situated learning (Campana, 2014), where teachers construct their own learning through an inquiry-approach (Brooks & Gibson, 2012). This is different from the top-down approach of school based professional development agendas. Professional learning is seen to be grounded by several theories such as Vygotsky’s theory of social constructivism and theories of situated cognition (Parsons, Parsons, Morewood, & Ankrum, 2016). Social constructivists believe that individuals actively construct learning through social interactions with others. In addition, situated theorists posit that learning occurs within a specific context and is shared across participants. Learning is a matter of creating meaning from the activities of everyday experiences Thus, in educational settings, teachers learn through social interaction that are based on their professional activities in their classrooms (Putnam & Borko, 2000).

Approaches and affordances of Professional Learning

With the emergence of technology advancement, teachers have greater alternatives to learning (Loughran, 2010) with learning taking place online or in face to face settings. In online settings, technology-mediated learning (Aubusson, Schuck, & Burden, 2009; Stevenson et al., 2016) through online social networks (Hsiao, Brouns, Kester, & Sloep, 2013) are increasingly seen as opportunistic. Social media as learning platforms require teachers to self-direct their learning based on self-interest or needs (Ambler, 2016) without being restricted by certain school organized programs (Day & Sachs, 2004). Online learning enables teachers to have more diverse networks and anytime discussions than they can do in their school face-to-face settings (schlager, Farooq, Fusco, Schnak, & Dwyer, 2009).

Teachers used social networking sites like Twitter, Facebook, blogs, wiki mainly for networking and resourcing— that is, finding colleague whom are like-minded and relevant educational resources (Carpenter & Krutka, 2015; Davis, 2015; Forte, Humphreys & Park 2012; Hutchison & Colwell, 2017; Kim, Miller, Herbert, Pedersen & Loving, 2012; Ranieri, Manca & Fini, 2012; Veletsianos, 2011; Visser, Evering & Barrett, 2014; Wesely, 2013). For many teachers, using social network for these activities contributes to their professional learning and becomes embedded in their daily routine, which improved their teaching practice and their own understanding of the relevant content or pedagogy (Baran & Correia, 2014; Huei-Tse Hou, Kuo-En Chang & Yao-Ting Sung 2009; Kelly & Antonio, 2016; Khan, 2014; Macia & García, 2016; Twining, Raffaghelli, Albion & Knezek, 2013; Tour, 2017; Trust, Krutka & Carpenter, 2016; Zhang, Liu, Chen, Wang, & Huang 2017.). Teachers in these studies who actively networked felt unsure of the usefulness of time spent on school based professional development or one-shot workshops for relearning subject matter and when given time preferred to work with colleagues to use it productively. The benefits and challenges faced by the participants in their professional learning are explained in the next section.

Barriers to professional learning through social media can be related to individual and external factors and the nature of online learning itself. Individual factors involve teachers’ willingness to engage with social media and provide the time to learn a new application as well as the time to maintain engagement. Keeping up to date with the rapid development and usage of digital technologies still remains a challenge (Bimrose, Kettunen, & Goddard, 2015). Also learning is the individual teachers’ responsibility without recourse to support or direct input from other user and or external assessment or complicacy requirements. Thus as Hood (2017) contends, knowledge gained online remains invisible (Hood, 2017). Additionally, it is the individual
teacher who decides what they want to do with the ‘new’ knowledge. External factors may include heavy workloads and busy nature of teaching and an unsupportive school culture or policy. Research has long suggested greater support for teacher professional learning as part of their professional practice (Parsons et al., 2016). In addition, the nature of online learning with regard to networking, collaboration for knowledge construction, sharing and feedback does not automatically occur (Kester et al., 2007). Successful online knowledge sharing depends on the communication between one that possesses knowledge and the other that needs to construct knowledge (Hsiao et al., 2013). By nature, participants of online learning are heterogeneous with different learning purposes, academic backgrounds, competence levels, and experiences, as well as knowledge about the given learning topics (Van Rosmalen et al., 2006). This imposes cognitive load demands such as to allocate cognitive resources, to explore what other participants in the network harbours, to interact with them, and finally to find a suitable collaborator which is not directly related to learning (Hsiao et al., 2013). As a consequence, the nature of learning online adds some degree of complexity to its process.

This literature has reviewed some of the differences between traditional professional development and online professional learning inclusive of approaches and affordances. In focusing more specifically on Impact, we turn now to investigating how teachers learn online together with understanding how this impacts theirs or others learning.

**Research Method**

The research project was titled ‘Professional learning in an Online World’. This qualitative study involved fifteen ICT-expert teachers from three different countries: Queensland-Australia, Belgium-Europe and Indiana-United States of America. The diversity of locality was chosen to mirror the notion of working online, the space/temporal flexibility where colleagues around the world collaborate. The teachers were targeted as participants (Intensity Sampling- Teddlie and Yu, 2007). Each researcher chose five participants based on the criteria that they were (1) perceived by their local educational communities as an ‘ICT-expert’; (2) that they provided professional development to their colleagues at school, district or state level; and/or (3) they had won an award for their ICT-expertise. Table 1 provides a list of the teachers (pseudonyms) with their relative ICT expertise.

**Table 1 Teacher participant details**

<table>
<thead>
<tr>
<th>Australia</th>
<th>Belgium</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Donna</td>
<td>Brad</td>
<td>Barbara</td>
</tr>
<tr>
<td>Leader of E-Learning and Library Services in Secondary School</td>
<td>PD ICT facilitator, Researcher across all school contexts</td>
<td>Ambassador for Tech companies, PD facilitator, Kindergarten</td>
</tr>
<tr>
<td>James</td>
<td>Brian</td>
<td>Carol</td>
</tr>
<tr>
<td>Online Specialist and peer coach, Teaching year 5</td>
<td>Pedagogical ICT facilitator, across all school contexts</td>
<td>PD provider, Secondary School</td>
</tr>
</tbody>
</table>
The main data collection tool was semi-structured interviews and comprised eight questions that included background (to identify expertise and build rapport), conceptualisation of professional learning, affordances and a behavioural event sequence that guided each teacher in explicating their learning online to application in the classroom. The three researchers from different locations were unable to co-interview. As such an interview schedule was co-developed with the acknowledgment that ebb and flow may alter phasing and sequencing of the questions. This ensured some flexibility associated with context to ensure that personalised views of networked online learning could be captured. Oppenheim (1992) and Patton (1980) both supported this approach to interviewing as the purpose was to enable the participant to talk candidly, with emotion (and passion) and honesty, especially in the context of experiences that do not comply with policies, culture, and standardised professional development activities. Interviews were held during the academic year between June 2016 - June 2017. Each teacher received the interview schedules prior to the interview to familiarise themselves. All interviews were transcribed and adhered to ethical requirements (GU Ref No: 2016/656).

Interview data was analysed through an inductive thematic process of examining, comparing, conceptualising and categorising the data (Strauss and Corbin, 1990). Inductive codes were assigned to initial larger segments of data that described a new theme. Two coders individually coded one interview from the same respondent. Subsequently, the coded units were compared in order to discuss disagreements, refine categories and develop a shared coding scheme. During the data analysis of the other teachers, the coding was discussed among the researchers to safeguard the quality of the interpretative data. All disagreements and interpretations were resolved through discussion. Finally, patterns and differences across the respondents were identified through constant comparisons. As this paper deals with conceptualisations of what ‘professional learning’ means in association to ‘learning actions’ in social media, where the link between thought and action is critical, a more holistic representation of teachers’ use of social media was required. After the thematic analysis and an increased familiarity with all data, four teachers were chosen to be represented in this paper through the construction of short vignettes on their professional learning practice. These teachers were chosen based on Asmussen and Creswell’s (1995) sampling strategy to select unusual cases with maximum variation within representative clusters. Descriptive content is placed around direct interview excerpts to present each vignette.
Results

Barbara – “I search Pinterest, I search education blogs, I reach out on Twitter to companies and stuff, and I discovered Book Creator”.

Barbara teaches in early-years classrooms. She has always liked to tinker with technologies and has been able to trial the newest tech-tools in her classroom due to connecting with software companies early in her teaching career. She had recently been using Seesaw, Pinterest, Pic Collage, Chatter Pix, and Canvas. She believed that children need to be taught how to work with ICT because “that's the skills they'll need in their future careers” and she wants to get parents involved: “I create pages in Canvas of videos of their Story of the Week or videos of the Poem of the Week... then give those parents the QR code.” She considers professional development as more intensive learning relating to the development of strategies you’d use all the time. Professional learning is more informal and superficial in that “I'm always reading something new, or researching something new. Maybe not diving into it completely. Barbara would spend 6 to 7 hours a week on social media. “I search Pinterest, I search education blogs, I reach out on Twitter to companies and stuff, and I discovered Book Creator”. She networks because the teachers at her school are “seasoned, more set in your ways, and not as apt to try new things”. In comparison, she considers her online colleagues as “great educators to follow on Twitter, and they're sharing things all the time”. However, there is an element of tension associated with being an ICT innovator in her workplace, “I see people sometimes turn their nose up at that. When teachers do try to make themselves better, it's kind of looked at us ... They think that I think that I'm better than them.” She expresses this competitive culture in her work environment not online, and it has not deterred her from self-improvement as “Teaching is my life...And I just want to continually be better, I don't want to stay stagnant”.

Kate – “When you meet the people who are on Twitter face to face, the bond gets greater”

Kate had been teaching for 30 years and is an ICT specialist teacher who provides teachers with curriculum support for the integration of ICT in all subjects. Her use of social media is directed towards meeting colleagues she can collaborate with and keep up-to-date. She explains her focus “I kept in contact with key people I thought I need to stay in touch with because they've got their finger on the pulse. I have been a broad network of those people across different school sectors and across state, and now across the world”. She joins twitter chats, reads blogs and attends conferences. She thinks that professional development is a more formal event in staff meetings, while professional learning is using ‘Twitter and going to conferences and learning what you need to make your classroom work or ideas of innovation that will move your school forward”. Making connection with colleagues is crucial for Kate. She finds like-minded colleagues on Twitter but when she meets them face to face at conferences or Pub PD, then the opportunity to collaborate with these colleagues is greater. She explains this “When you meet the people who are on Twitter face to face, the bond gets greater, the learning network gets stronger the more you meet these people.” She met a teacher whom she followed on Twitter and “we got kids together to collaborate on projects that involved tech”. This preference to develop more personal relationships was also evident in her engagement in Twitter chats as she describes that “I'm not active in the chats” instead she prefers to responds to colleagues by having “stacks of discussions that are private messages on Twitter”. For Kate, she uses social media to make connections with other teachers, that lead to collaborative curriculum development as well as maintaining her currency with ICT innovations.
Donna — “What I can count in compliance to keep the boxes more or less.”

Donna had been teaching more than 20 years. Her current position is a leader of E-learning and library services at her school. To keep abreast “of the big picture stuff” she does many things like conferences- both educational and IT management at national and local levels, mailing lists, state committee meetings. For curriculum needs she uses Twitter “I follow quality people. If you see a hashtag that's pretty active, there are some people chatting ... so if I'm waiting for a train I might just click through the things and see what's happening. I would say (I spend) maybe 20 hours a week,” on social media. She focuses on what people are doing and what the challenges are, “I get motivated to just lurk in” and figure out "Am I on the right track?" Keeping up to date as well as qualifying what she is doing at her school are Donna’s main reasons for social media use. Donna believed that professional development is related to career development while professional learning is “much more task focused or focused on practical skills” . She was aware of the benefits of learning through personal learning networks, but still thought attending formal school based professional development was valid. She said this was closely related with the policy of minimum hour for attending accredited professional activity. She observed this policy influenced teachers’ action, she elaborated that “Often the first question that's asked is not what is the PD, it's is it accredited? Is this going to count?” Although she spent around 20 hours a week on professional learning through social media, she said “You won't be able to count for my accredited hours, so I'll have to do so many accredited hours each year to maintain my teacher registration." She mentioned that “it's a lot of work to get yourself to a conference during school hours” but it is “what I can count in compliance to tick the boxes more or less.” And she regrettably said that “I think in the future it's going to be closely connected with compliance, unfortunately”. For Donna, learning though social media is a matter of seeing what is currently happening for curriculum validation.

Tasha- “I share more through social media, because there's much more interaction than in real life”

Tasha is a language teacher in Belgium. She spends around 4-5 hours per week in social media to connect with her professional learning network as she lives on an isolated island. “I get a lot of inputs from other schools, from other teachers, and it's easier through social media”. At her school she finds it's very difficult to get teachers to share their materials or ideas, because they are always very insecure about their work. She mentioned that people often said “I didn't feel secure enough about my material. I'm very afraid that my colleagues will say that it's crap.”. She adds “the school system doesn't encourage the sharing part...I never see these people. We don't have much time to sit together, and to talk.” She admitted that this unassertive nature of sharing was part of her culture which was proving an obstacle for people to learn. She thought social media was a solution to this cultural boundary, “There's something about social media, I don't know, I'm not a social media expert, but there's something about social media that it makes those boundaries go away.” When she was asked about attending formal professional development she stated that “I don't believe in professional development,...because how does that work?” She described how teachers could be overwhelmed with syllabus and several ICT integration ideas from one professional development they had attended but eventually “...nothing happens afterwards with it.” She mentioned that attending out of school PD is impractical. Tasha’s uses social media as a platform to share curriculum resources. She says “I think there has to be something about sharing, perhaps, because that's my whole thing. That's
why I do these things... It's about sharing, and it's about connecting and learning from each other”. Sharing is not an outward process of posting resources online, by sharing Tasha means a collaborative activity with a feedback cycle. She explains this, “in social media, if I share something, what happens a lot, people adopt, for example, my material. They send it back. That way it's a win-win.” She liked the idea to learn from feedback she gains from other teachers online as “otherwise, I'm always in my own classroom, and I know what works there, but I don't have the full vision.” Her need to share through social media is driven by her culture context.

Discussion with Implications

As presented in the four cases above, teachers conceive of professional development and professional learning in different ways which affect their learning intentions when they engage through social media. All ICT expert teachers thought of professional learning as informal learning on a casual anytime basis that has more relevance to curriculum design and classroom strategies. They all spent considerable time weekly on social media and were trying to keep abreast of technological innovations. For Barbara, her intentions were to curate the latest educational resources so that she was up to date with the newest technologies to use in classroom. Her liaisons with computer companies also supports this collecting of tools focus. She wanted to ensure her students were using technologies that were considered effective by her online colleagues but there was also an underlying element of competitiveness that existed at her school which spurred her to find new tools. Kate, by contrast, was not motivated by competition, rather her intentions were based on developing more personal relationships with her online colleagues. She sought the newest ICT ideas as a means of finding like-minded colleagues whom she could work more extensively with once she had physically met them. This belief is supported by Campana (2014) who points out that combining online learning engagement with face to face interaction is influential to making informal learning more effective. Donna’s learning intention was to stay current of new ideas as a means of curriculum and pedagogical validation. To achieve this goal, she attended conferences as well as spending a lot of time in social media, lurking. This is in contrast to Kate and Tasha who were active in personal chats and sharing activities respectively. Donna, on the other hand, did not actively contribute, preferring to monitor online chats. Booth & Kellogg (2014) have emphasised that in online learning platform, teachers can form a flexible collaborative learning community where learning occurs as a result of interactions among users or as Hsiao et al. (2013) refers to communication between one that possesses knowledge and the other that needs to construct knowledge. In this case, Donna did not engage in taking and giving as part of a collaborative community. But Tasha did. It was her main intention to ensure that she was sharing, by posting her educational resources for use and feedback from her professional learning network. This sharing intention was fuelled by both physical isolation, as well as cultural isolation, in the sense that culturally her school colleagues maintain a self-consciousness about their professional capabilities and did not like to collaborate.

There are three major findings from these four cases. Firstly, all teachers believed that learning through social media is considered informal learning focused at the classroom level. This aligned with current literature (Ambler, 2016; Day & Sachs, 2004). Secondly, there were a range of learning intentions that actioned different behaviours online: Barbara curated tech tools to find the latest technologies; Kate followed specific like-minded colleagues to build personal relationships; Donna lurked in chats to validate her curriculum approaches; and Tasha
posted her curriculum resources seeking feedback from her network. These online activities extend beyond what is currently known as ‘networking’ and ‘sharing’ resources for professional learning through social networks (Trust, Krutka & Carpenter, 2016). The link between intention and action presents new findings on professional learning reasoning and action that help conceptualise learning practice online. In responding to the research aims of this paper, there are two different intentions evident in action online- Self-impact and My-impact. Self-impact can be defined as reasoning to develop the individual, the self. Both Barbara with her learning intention set on curating tools and Donna’s with her learning intentions set on validating her practices, evidence a Self-impact approach to professional learning through social media. Alternatively, My-impact approach is evidenced in Kate’s need for building personal relationships and Tasha’s intention of sharing through her network. Both of these teachers saw their impact in relation to others.

The third major finding, is evident in the cultural interplay shaping professional learning. Tensions exist between a culture of competition that can support engagement, deter engagement and or transpose engagement. Barbara searched for the latest technological tools to maintain her expertise driven by competition in her school context; Kate was adverse to competition seeking more personal relationships; Donna lurked to validate which acknowledged a level of competition; while Tasha was able to break free of the competitive ‘I’m not good enough’ cultural context to share online. Interestingly, Twitter was found to provide an environment that did not maintain a culture of competition. Further research is needed to explore the cultural boundaries associated with professional learning through social media as currently little is known about this causal relationship.

The tension between professional development considered as deriving from a school-based agenda and professional learning as deriving from self-directed needs or interest based agenda suggests implications for what can firstly can be considered as valuable and effective, and secondly as compliant to policy and or external accreditation bodies. Reshaping our understanding of what is considered effective for both how teachers learn and also what they learn in an age where learning opportunity is available 24/7 and information is not only prolific but generated by teachers for teachers, is essential but also must make impact on educational authorities in charge of compliancy measures. The findings of this research also suggest the opportunity for a concomitant relationship to develop between professional development and professional learning in social media to support and leverage all teachers’ learning intentions.
References


Integrating 3D Printing with Teaching at Monash College

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**Introduction**

3D printing is an umbrella term for any additive manufacturing process whereby a working material, typically plastic, is used to create a tangible replica of a computer model through an incremental process (Cummins, 2010). These models can be found online in user generated libraries and repositories although the true power of 3D printing is seen when models are created by the user to suit a specific and unique need using Computer Aided Design (CAD) software such as AutoDesk Inventor or Google SketchUp.

3D printing technologies are becoming increasingly ubiquitous and encourage a new range of skills and capabilities to be expressed for both educators and students. The obvious use for these technologies is to be used directly in the classroom to teach design skills but they also have the ability to be used by educators to create teaching aids to enhance learning (Eady and Lockyer, 2013). 3D design skills, along with programing can be thought of as modern day soft skills, especially for people in the STEM sector, in that being able to communicate your ideas as an engineer or scientist can often be intrinsically linked to your ability to program, create models and represent complex and difficult ideas, in a simplified or straightforward manner. These skills would traditionally fall under the banner of problem solving, critical thinking and creativity, however it is also linked to technical communication.

Jamieson-Proctor and Albion (2016) present the importance of creative thinking in preparing young people to respond to future challenges and opportunities by allowing them to experience the richness of creative thinking and learning. Jamison-Proctor and Albion (2016) citing NACCCE, 1999 discuss some of the features of creative learning. The four features discussed are students experiencing innovation in the classroom, control over their activities and their evolution, together with a sense of their relevance and ownership of their learning. They further discuss how these features are also characteristic of creative teaching. It will be shown that, by utilising 3D design and 3D printing, it is possible to empower both students and teachers in each of these features in a relatively simple but effective manner.

Just as most teachers today are comfortable with the use of PowerPoint to develop presentations or an LMS to develop an online quiz, providing teachers with 3D design and printing skills, affords them the ability to be involved in the entire design process of developing interactive and visual content for their classes. The increased level of control in content development allows teachers to embed their own experience in their materials and provides them with a greater sense of ownership of it. This leads to greater and more effective use of the tools in the classroom.

Eady and Lockyer (2013) discuss how students are required to create a multitude of products
in the school environment and how these ideas can be demonstrated through various means. They illustrate the importance of the use of technology while maintaining the importance of students being able to create and highlight changes in curriculum documents that address technology while maintaining the fundamental values for learning. While it is important to apply new technologies in the classroom, technology is protean in nature. It is therefore, also important to use current technology to develop and enhance existing pedagogical practices. This paper will explore the use of 3D printers at Monash College Diplomas as a tool to develop interactive teaching materials and teaching aids to enhance student learning as well as to discuss how 3D printing and design can be taught to educators and students. The next section will outline how 3D printing can be used to develop custom and unique visual aids to enhance teaching practice and following that our approach to teaching 3D modelling and printing to students will be explored. Lastly this paper will be concluded with a discussion of the difficulty of implementing these practices in an educational setting.

3D Printing to Enhance Teaching

This section will discuss how 3D printing has been used at Monash College as an aid to teaching in the classroom. Two types of teacher aids are discussed here, interactive aids and visual aids. Interactive aids are those objects or models that are designed by teachers for students to use in class as part of some activity. Visual aids are models that are created purely for the purpose of demonstrating complex or hard to understand concepts, typically as a replacement or in addition to a drawing or photo.

Interactive and visual aids are important for learning as it provides a kinaesthetic avenue for learners to engage in the materials and 3D printing technology provides a relatively easy way for teachers to incorporate this aspect into their lessons (Oxford, 2001). It is important to note that these results can also be achieved by using virtual reality which is becoming more accessible through technologies such as Google Cardboard, Oculus Rift and the HTC Vive, however there are significant cost and technological limitations to consider when using these technologies. A decent VR setup may cost similar to a 3D printer, however a 3D printer can be utilised by a whole classroom at once, whereas a similar engagement would require a VR headset for each user. The other limiting factor to VR technologies is in the skill and time requirements to create useful and effective virtual environments. While content for 3D printing can often be found online, it is not significantly onerous to learn the skills oneself (as discussed in a later section), however the skills required to develop not only detailed and complete virtual worlds, but ones that are interactive and serve some particular educational purpose.

The other counter argument to using 3D printing to produce visual aids is the age-old adage of not reinventing the wheel, or in other words, if I can buy it, why should I spend the time to make it? While this can be true sometimes it can often be just as likely that no solution as specific as the one you are searching for exists. Even if that solution does exists and is available for purchase, there are a number of limitations to consider, such as:

- Difficulties in sourcing fit for purpose items that meet all the requirements for a particular subject.
- Adapting or changing the items as requirements evolve.
- Cost of parts.
- Time limitations.
- Issues with supplier.
With the above discussion in mind the authors would like you to consider the following examples of interactive and visual aids that have been developed for use at Monash College.

**Interactive Aids**

**Bridge Joints for Engineering Design**
A universal building block to act as joints for spaghetti bridges and structures was designed for MCD4270, “Engineering design: lighter, faster, stronger” shown in Fig. 1. Previously, the students were required to use glue and tape to construct their structures. This was a tedious process which didn’t last and limited the time students spent on creativity and their designs. This is an ideal example of where printing technology can be used to reduce the amount of time teachers spend on monitoring simple mechanical skills and instead focus on improving the creative problem solving skills of students. Additionally, by using the building blocks students have greater freedom to experiment with more elaborate designs.

![Universal building block and spaghetti bridge example](image1.png)

**Figure 1: From Left to Right: Universal building block, Spaghetti bridge example.**

**Molecule Building Blocks for Chemistry**
A collection of molecular building blocks were designed for the various chemistry subjects that are delivered at Monash College. These building blocks are designed to be incorporated into a commercially available kit that is generic in nature and restrict the teachers to producing a fixed set of molecular structures. Conversely, the 3D printed parts were designed to replicate unique or more specific details in molecular structures and since the models are internally made improvements or adaptations in the design are quick, easy and inexpensive. An example of one of these parts is shown in Fig. 2. This figure shows a molecule with two links, 180 degrees apart. This part was not available in the commercially available set despite being an important feature for this particular molecule.

In general, these building blocks also allow students to create and explore complex molecular structures and this process encourages tactile learning (Oxford, 2001).
Visual Aids
Model UN name plates for Humanities

To create a more immersive experience for students participating in a model UN the authors designed and printed a set of country name plates and flag holders as shown in Fig. 3. While these name plates provide a purely decorational function they are a perfect example of an item that would traditionally be difficult or expensive to source, so thus the teacher would resort to spending a weekend making something rudimentary from craft materials. In this case, the 3D printer has been used to improve productivity, freeing up more time for the teacher to develop high quality teach materials.

Atomic Models for Physics/Chemistry

As well the chemical building blocks mentioned in the previous section, the authors have also produced a wide range of other 3D models to demonstrate chemical and physical properties or structures across all of our physics and chemistry subjects. These concepts and structures were previously described using a 2D image presented in lecture slides and students often struggled to understand the very specific geometry of these complex structures, however, by 3D printing them instead students can physically interact with these shapes and instantly gain an understanding of the angles and shapes involved. These objects include chemical compounds, atomic arrangements and models of the electron cloud and electron orbitals, shown in Fig. 4 alongside their more traditional 2D counterparts.
I-Beam and T-Beam models for Engineering

For an introductory mechanical/civil engineering subject, the authors designed and printed a model of an I-beam and a T-beam. This model was primarily used as a teacher's visual aid that they could easily rotate, to point to and highlight different important aspects of these structures. The 3D model was also used to show the loading conditions of these structures. This was ideal because the flexibility of the PLA plastic produced exaggerated deflections and bending stresses.

Figure 5: An I-beam model.

Feedback

Informal interviews were used to collect teachers’ feelings and thoughts in regards to using 3D printed teaching materials after an object was produced for them. During the interviews, teachers were encouraged to discuss their experience working with the 3D printed models, modellers and students in the classroom. In general teachers indicated enthusiasm and enjoyment in the process and some have sought further training to develop their own 3D design skills.
The authors discovered while undertaking this work that the hardest aspect of uptake in 3D printing technology as a teaching tool was in getting the teachers to identify what aspects of their curriculum could be improved with 3D printed objects. The authors found that once the teachers had seen an example of a product that was relevant and effective, they often came back with several more requests. Teachers also spoke about how having access to these tools and changed their way of thinking in terms of the way they can develop their content and how they think about the materials to include. After participating in this process the authors found that teachers were more engaged in curriculum design and improvement, would be more open to collaboration which in turn lead to cross pollination of ideas between related fields (e.g. I saw chemistry did and would like something like that for my class, etc.).

**3D Printing to Enhance Learning**

3D printing can also be used as a platform for teaching correct engineering design process to enhance student learning. By learning how to 3D print students are learning fundamental skills around proper design process, iteration and prototyping. This process has the added benefit of providing STEM students an otherwise unavailable creative as part of their studies, where they can be encouraged to think laterally to solve complex problems and improve their engineering soft skills. This section will discuss how 3D modelling and 3D printing skills were taught at Monash College as part of two subjects, MCD1160: Introductory Engineering Computing and MCD1470: Engineering Practice.

**Learning in Introductory Engineering Computing**

Introductory Engineering Computing is a subject at Monash College, completed by Science, IT and Engineering students as they transition to university. This subject teaches students to solve problems of practical significance by applying scientific and technical knowledge, common sense, and experience. It is expected of students to investigate, explore and discuss engineering concepts and issues and solve problems in class using computers.

In this subject, 3D printing and modelling was taught as a skill that students will require in their fields of study as well as to foster the soft skill areas of creativity, critical thinking and communication, which form part of the 4C’s that are essential knowledge and skills in ensuring student preparation for higher education, career challenges and a globally competitive workforce in the 21st century (Partnership for 21st Century Skills, 2011). These tools were also used to enhance interactivity within the labs.

Casimaty and Henderson (2016) discuss the importance of creativity in learning, to aid with problem-solving, growth and innovation and how one of the essential characteristics in creativity is risk-taking. They further discusses how the use of ICT can facilitate students taking risks. Through the use of 3D printing and design, students are intrinsically encouraged to take risks.

As part of their 1st assignment students in MCD1160 are required to design a robot car that
navigates a track autonomously. Students have a choice of using a simple robot designed by staff that has some flaws or creating their own. Students that chose to design robots made numerous errors in their designs, particularly those who were more ambitious and innovative in their approach. Due to the low-cost of the printing materials, these students were given the chance to correct these mistakes or make improvements to their designs and re-print their designs. The use of the 3D design software allowed them to visualize their creative designs before printing and also provided them with the incentive to become more ambitious in their designs. By viewing their colleagues designs, students that were more reserved or reluctant to take risks or develop their own robots, developed and began undertaking more ambitious projects. This is illustrated in figures 6 and 7 that shows a single student’s design as it evolved into the final product. It is the fostering of this intrinsic motivation of students as discussed by Casimaty and Henderson (2016) that leads to a higher propensity for an individual to take risks and is fostered through the use of problem-solving tasks assisted by 3D printing.

Figure 6: A student’s initial design with modifications made to add a steering arm.
Learning in Engineering Practice

Engineering Practice is a subject at Monash College, primarily completed by our Science and IT students and counts for credit for a first year subject at the university. This subject teaches students fundamental engineering design skills and focuses on communication, presentation, project management and engineering design. Compared to Introductory Engineering Computing, Engineering Practice doesn’t provide students any lessons on 3D printing or 3D modelling. Instead students work in groups and are encouraged to come up with their own solution to an engineering problem and 3D printing is just one of many possible tools that they can use to solve that problem. According to Jamieson-Proctor & Albion (2016, citing Batham, Jamieson-Proctor, & Albion, 2014; Jamieson-Proctor & Larkin, 2012; Proctor, 1999; Proctor & Burnett, 2002), evidence suggests that students’ creative thinking can be facilitated and even significantly enhanced when they work collaboratively with access to appropriate digital technologies. Often the students that use 3D printing are those that come from MCD1160 or have previous experience in 3D modelling and are curious to how the 3D printing process works. There are also some students who are intrigued by 3D printing and seek out additional support outside of scheduled class time, either in consultations or through our mechatronics club.

Feedback

Feedback was obtained from tutors and teachers on their observations of student behaviour and engagement within the classroom. Based on this feedback there was a unanimous belief that students were more engaged with the content being taught, especially during the weeks when 3D design and printing was being taught. Students found these activities to be fun and felt that it provided them with a creative outlet. This is reflected in the number of modifications and re-submissions that students submitted for printing and in some cases, students continued to request prints after the assignment was completed.

Student Evaluation of Teaching and Units (SETU)

The SETU is a survey that occurs each trimester at Monash College and Monash University. This survey asks a predefined set of questions to all students across each of their subjects to gauge student perceptions about teacher quality, individual staff and student satisfaction with subject material.
SETU data for MCD1160 showed significant improvements once 3D printing and design was introduced in the units. Over the past four trimesters that data was collected, the satisfaction component of the unit improved from being consistently below 4 (3.85 and 3.88) to above 4 during the last two trimesters (4.58 and 4.38). While ratings were improved in all areas, of notable increases were questions related to improvement of thinking skills (3.88, 4.2, 4.58 and 4.64) and problem solving skills (3.81, 4.13, 4.5 and 4.43).

3D Printing Learning Curve

3D printing requires mastery of several different processes and softwares including some type of CAD software, a slicer program and interaction with the 3D printer itself. CAD software is used to create or modify 3D models, typically these programs are very powerful and expensive and have large online support communities however there are some simple or smaller entry level programs such as Google SketchUp or Simplify3D. Once a user has generated or found a 3D model, the next step is to use a slicer program. Slicer programs are usually made by 3D printer manufacturers and they work by converting a 3D model into a series of 2D motion paths for the 3D printer to follow. The last part of this process is the 3D printer itself, which will read the file output by the slicer and control the motors and print head to produce the part.

At Monash College we made the decision to use AutoCAD Inventor as our 3D modelling software, FlashPrint as our slicer and the FlashForge Inventor as our 3D printer. Being able to 3D print involves understanding of all of these components and this section will discuss how these parts are taught to both students and teachers. This section will also discuss some of the issues that were encountered during this process and how they were overcome.

Teacher

One area of concern for teachers was the ability for them to learn the skills required to use the 3D modelling software and 3D printer without continued dependence on experienced staff. In order to investigate the relative ease at which the skills could be learned, three teachers were trained on the modelling and printing process by using a few tutorials, self-learning, and a few discussions with an experienced 3D designer. Once complete these teachers went on to design a number of models on their own. Based on the experience of the teachers, after a few relatively short tutorials, teachers could become competent with the software. These short tutorials could typically be included in Professional Development.

Student

The students at Monash College are typically of a non-English speaking background. This is compounded by the fact that MCD1160 is part of a transitional education program, designed to bring students up to the high standard required for university entry. One of the teachers’ concerns for teaching 3D modelling and 3D printing was the students’ ability to cope with potentially large amounts of new jargon associated with CAD and 3D printing. This proved to not be an issue and in fact, this tended to put all of the students on a more level playing field as the English speaking students knew just as few words as the non-English speaking students. Additionally, due to the digital nature of this work, students were able to configure the software to run in their native languages so they could more easily follow along with the teacher’s instructions.
Another issue we encountered was that during the initial implementation of the subject, the 3D design component was taught over two consecutive weeks with four labs of 2 hours each. While students were successful in completing the labs and their tasks, they struggled when it came to implementing more complex designs such as their robots. This is due to the limited time they had to investigate and explore the software. By separating the weeks in which students learned 3D design and printing, they were able to investigate the software and explore modelling. A simple 3D housing was also made optional for assignment 1 with most students choosing to submit a design. They were then introduced to more complex concepts during the second week presented at a later time, which resulted in more creative designs for their robots.

Conclusion

The use of 3D printers as a tool at Monash College was shown to improve engagement in a number of subjects. They provided for an additional outlet in which teachers could express creativity in designing lessons and creating custom content for their subjects. Students’ creativity and interactivity in lessons was enhanced due to the use of 3D printed models. Increased collaboration and discussion was also generated between teachers in what types of content to create and how best to integrate this into the lessons which generated interest from other teachers leading to a cross pollination of ideas.

References


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High Impact Learning and Teaching using 3D Design and 3D Printing in Primary School Makerspaces

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The Push to Integrate 3D Design and 3D Printing using Makerspaces

With an increasing international focus on STEM education, the makerspaces movement has gained much momentum in recent years. In Australia, the economic and industrial relevance of STEM for the country’s future has been recognised in recent policy announcements calling for “a core STEM education for all students – encompassing inspirational teaching, inquiry-based learning and critical thinking” (Office of the Chief Scientist, 2014, p. 20). The push for integrated, inquiry-based STEM education is also reflected in recent curriculum changes such as the Design and Technologies F-10 Syllabus (Australian Curriculum and Reporting Authority, 2014), which includes a specific focus on the early years, emphasising engineering principles, complex design solutions, two- and three-dimensional modelling and graphical representation. Consideration of how science, technology, engineering and mathematics are practised and applied in real world contexts has further prompted efforts to integrate STEM disciplines into learning and teaching. In schools, universities, and community centres throughout the world, makerspaces have become sites in which such learning is valued and realised.

Sheridan, et. al. (2014) define makerspaces as “informal sites for creative production in art, science, and engineering where people of all ages blend digital and physical technologies to explore ideas, learn technical skills, and create new products” (p. 505). Makerspaces often involve “a physical space with shared resources to pursue technical projects of personal interest with the support of a maker community” (Oliver, 2016a, p. 160). Making can occur through a range of activities, such as “textile craft, robotics, cooking, wood-crafts, electronics, digital fabrication, mechanical repair, or creation” (Peppler & Bender, 2013, p. 13). Often associated with the makerspaces movement, 3 Dimensional (3D) printing enables virtual designs to be physically created using digital technologies and thus reified to represent the solution to the posed design problems. Common software applications used for designing 3D models for later printing include Sketchup, Tinkercad, and Makers Empire.

A pertinent issue is the lack of empirical research on the educational use of 3D design and 3D printing in makerspaces. Without this research, educators – especially those new to 3D printing and maker pedagogies – may wonder what might or might not be appropriate practice. Although makerspaces and 3D design activities have been espoused as popular contemporary approaches in education, further evidence is needed to determine effects on learning. While tactile and student-centred approaches are often advocated in the younger years of schooling, further research exploring 3D printing and makerspaces in early primary school classes is particularly warranted. To address these gaps in the literature, this paper presents findings from a collective case study that examined both teacher professional learning and teachers’
implementation of makerspaces in twenty-four K-2 classrooms (students aged approximately 5-8 years old). This study aimed to characterise the learning that occurred in makerspaces and to examine the impact of makerspace-based activities on learning outcomes, learner engagement and teachers.

**Learning and Teaching in Makerspaces**

The learning theory that is most often invoked to explain learning in makerspaces is constructionism. Building on the earlier theory of constructivism, constructionists hold that learning is most effective when it occurs through participation and embodies learner-led inquiry, creativity and making. The leading exponent of the theory, Papert (1986) states that constructionism “takes a view of learning as a reconstruction rather than as a transmission of knowledge… Then we extend the idea of manipulative materials to the idea that learning is most effective when part of an activity the learner experiences as constructing a meaningful product” (p. 2). In this context, maker pedagogies have also been linked to other learning theories such as socio-constructivism, where learners learn through scaffolded collaboration with their teacher and peers (Vygotsky, 1987). Associations with pragmatist learning (Dewey, 1916) through authentic experience, inquiry, and reflection are also evident.

In a review of findings across several studies, Oliver (2016b) argues that benefits of makerspace-based learning environments include that they can be student-directed and supportive of curious play, promoting tolerance of failure, encouraging peer collaboration, physically-sited, open for ongoing scheduled and unscheduled project work, and well-stocked with sourced materials and equipment. Martin (2015) defines the importance of a maker mindset as one that is playful, values new learning as well as accumulated knowledge, is failure-positive and collaborative. In their substantive review of makerspaces, Vossough & Bevan (2014) found that maker-based learning encourages participation in science environments, supports academic and disciplinary development, and creates communities of learners. Similarly, Martin (2015) proposes seven reasons why ‘making’ is a valuable learning activity, including that it 1) can align with curriculum demands of schools, 2) gives students access to sophisticated building and thinking, 3) encourages a culture of creativity, 4) fosters playfulness through tolerance of errors, 5) advocates a growth mindset, 6) provides learner choice, and 7) intrinsically incorporates learning through community. Across the recent literature, several pedagogical approaches have been recommended for teaching in makerspaces. These include sparking interest in the learning activity, sustaining participation through new ideas and encouragement, deepening participation through reflection or challenge, setting up a positive learning environment that encourages experimentation, supporting students to effectively document their work, and prescribing tasks that involve “low floors, high ceilings and wide walls” (Vossoughi & Bevan, 2014, p. 2).

However, there are several issues that need to be considered when integrating makerspaces into the curriculum. Forest et. al. (2014) regard safety, intellectual property, funding and expense as three issues that need immediate consideration when setting up a makerspace, while challenges surrounding makerspaces according to Slatter and Howard (2013) include the degree of technical expertise required, budgetary issues, ethical and legal issues such as intellectual property, and the possibility of printing contraband materials such as weapons. Halverson and Sheridan (2014) also note challenges of teaching and learning in maker environments where learning is less-regulated, possibly leading to ineffective delivery of learning outcomes. Such
issues point to adequate staff training as an issue to developing effective maker pedagogy (Moorefield-Lang, 2015), supporting calls for more explicit and detailed analyses of pedagogy development in maker environments. As Smith and Smith (2016) observe, there is a range of practice-oriented papers that present teaching ideas and explain basic maker concepts to those who may be unfamiliar with the domain, and other papers propose strategies for teaching in makerspaces based on distilled observations from the field (see, for example, Oliver, 2016b). However, these strategies tend to be based on single case studies, often involving the suggestions of one or two researchers or teachers rather than using broader samples or more systematic and in-depth analytic processes.

Method

The Makerspaces in Primary School Settings project was a research collaboration between Makers Empire – a company that develops 3D modelling and printing software for children – three participating NSW Department of Education schools from the Greater Sydney Region, and researchers from The Department of Educational Studies at Macquarie University. Makers Empire is 3D Design and Printing software that has been specifically created for easy use by children. Students can design 3D models on the touch screen interface of a tablet device such as an iPad, using a range of tools that have been built to make the 3D design process simple and intuitive. In addition to its use on iPads, the software is also freely available for desktop computers and Android devices. The platform allows students to save their creations to the cloud, includes a gamified tutorial system where students can earn ‘tokens’, and features a teachers-only dashboard for managing and monitoring activities. For more information see http://makerempire.com. The platform was an important component of this study because it supported 3D design activities for children in the early years of schooling.

The project involved a blended professional learning program delivered by Makers Empire trainers over seven weeks in Term 3 of 2017, and an implementation period in Term 4 of 2017, during which participating teachers designed and delivered units of work in their classes. Makerspace resources at each school included sets of iPads with the Makers Empire software, recently-installed 3D printers, and other tactile resources such as paper, glue, clay and so on that are generally available at all schools. The professional learning program included two days of intensive training in maker pedagogies, design software and 3D printing, an online Edmodo course page for technical support and further discussion, and four webinars delivered in afternoon time slots. To examine the efficacy of the teachers’ professional learning with makerspaces, online questionnaires were employed before and immediately after the professional learning program. Rating items for both the pre- and post-professional learning questionnaires were measured using a fully-anchored seven-point scale ranging from (0) “Strongly Disagree” to (6) “Strongly Agree”, with (3) being “Neither Agree nor Disagree”.

To gain a deeper understanding of how teachers implemented the units of work, and to closely examine learning outcomes and learner engagement, lesson observations (including researcher notes and photographs) were recorded for each of the twenty-four classrooms involved. Thirty-one lessons were observed by the research team during the implementation period (at least one lesson for each of the 24 classroom teachers), with visits occurring at different points in the teacher-delivered units of work. These lesson observations were analysed thematically in order to determine emergent issues and effects. Lesson codes were inductively developed to map each lesson to the four domains: (1) Student Learning (SL); (2) Learner Engagement (LE); (3)
Task Design (TD); and (4) Teaching Approaches (TA). During the implementation period all teachers were also asked to spend approximately twenty-five minutes each week documenting thoughts and observations about the lessons and were invited to include as examples relevant artefacts such as lesson plans, resources, units of work, and work samples. This provided a further source of validation and insight into learning and teaching processes. Following the modules, teacher focus groups involving all 24 classroom teachers and student paired interviews involving a selection of 34 students from across classes, were conducted to provide first-hand participant perspectives into the phenomenon of learning in makerspaces. All quantitative data were analysed using the *Statistical Package for the Social Sciences* (SPSS), Version 24, while qualitative data were inductively analysed through segmenting, coding and the creation of category systems in *QSR NVivo*, Version 11. Approval for undertaking the research activities in the study was granted by both the university Ethics Committee for the Faculty of Human Sciences, and the New South Wales Department of Education’s State Education Research Approval Process (SERAP). As part of this approval, pseudonyms have been used for teachers and students in this article.

Twenty-seven teachers were involved in the professional learning program and completed the pre-survey; of these, twenty-four had teaching roles, and participated in the implementation period. These teachers were predominantly female (n=26, 96.3%), with a majority (n=17, 63%) in their first ten years of service. All teachers were currently teaching in either *Early Stage 1* (Kindergarten) or *Stage 1* (Year 1 and Year 2), with class sizes ranging from approximately 20 to 24 students. At the time they joined the study, all teachers reported having no prior knowledge or experience teaching in makerspaces.

**Results**

Several learning designs were adopted by the teachers. Three examples are provided below to illustrate the practices observed in teachers’ makerspaces modules.

**Case 1 – Lighting Up the Shadowbox (Scaffolded Making)**

In the three Year 1 classrooms of Emma, Sophie and Abigail, the teachers used narratives to scaffold the design process and end products. Using three popular children’s stories – *The Gruffalo*, *The Mixed-Up Chameleon* and *The Three Little Pigs* – groups of students were allocated a section of a narrative to design and 3D-print characters to function in a shadow puppet class performance of the three texts at the end of the unit. Each section was scaffolded to include instructions for group members to follow, with the characters and setting closely matching the events in the narrative. Each teacher demonstrated a 2D design of one character in the class’s chosen narrative, and discussed with students the challenges of ensuring that the design would remain intact when moved, and create an effect shadow when placed in the ‘Shadowbox Theatre’ (see Figure 1). Researchers observed critical thinking as students “translated” their designs from paper (where they had been sketched) to 2D models in the app, hypothesising about how their completed designs would function effectively as shadow puppets. Most students attempted to create designs that resembled the original illustrations (as opposed to new characters), and there was group overlap in students designing the same characters.
In their reflections, all three teachers stressed the importance of modelling while allowing students some control. Emma explained that her “students need much more guided work for their project... [and] we need to explicitly talk about shadow puppets and students need more exposure to how they work”, though she noted that her earlier lessons were perhaps too scripted which resulted in many students getting through the lessons very quickly. Sophie indicated her preference for lessons with explicit instruction, arguing that her students “grasp skills better when focused on a set task”. Abigail’s preference was to provide “explicit instructions in how to use a tool, and then to allow students to explore [the use of] that tool in their designs”.

Case 2 – Discovery Time (Offline/Online Work Stations)
In two separate Kindergarten classrooms, Nadia’s and Sally’s students worked on a series of "discovery stations", comprising a range of mini-activities designed to improve skills in problem solving, communication and creativity (see Figure 2). In both classrooms, offline stations utilised different physical maker materials (including paddle pop sticks, Lego, cardboard, and glue), while an online activity in Nadia’s classroom involved the teacher "talking through" a Makers Empire tutorial as a small group of students completed the steps. After approximately 20 minutes of activity, students rotated stations. During these lessons, Nadia and Sally both commented that their lessons were precursors – for skills development – to the introduction of a larger makerspaces problem, which was scheduled to happen in lessons following.

Researchers observed students developing some problem-solving skills and, in Nadia’s app activity, literacy skills were evident as students followed the teacher’s verbal instructions as they navigated the app for the first time. Each station presented different opportunities to make 3D artefacts, affording some learner autonomy. Students responded creatively to the challenges, with some interesting and original designs emerging. The discussion components that both teachers included at the end of the lesson showcased students’ skills at communicating effectively with their peers. Reflecting on the lesson, Nadia described how she used both explicit instruction and modelling: “explicit instruction helps to establish a clear focus, and really directs students towards an evaluation/feedback phase... [whereas] modelling this process helps them develop and apply these skills on their own”. While supportive of explicit instruction, Sally felt that she needed to move away from it in future lessons, observing that many of her students “want to be shown exactly what to do rather than experiment”.

Figure 1 – 3D Printed Puppets in the Shadowbox Theatre
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97
Figure 2 - Discovery Time to Develop 3D Design Knowledge
Case 3 – Homes for Hermit Crabs (Authentic, Open-Ended Inquiry)
In a team-taught unit involving 3 Kindergarten and Year 1 classes, teachers Madalyn, Mackenzie and Timothy discussed with students the arrival of hermit crabs as class pets, and the importance of understanding their survival needs. The 6-week unit integrated science, technology, literacy and mathematics in a thematic investigation of the habitat of the hermit crab, culminating in the design and development of a range of accessories and ‘living essentials’ to include in each class’ crab tank. The unit was introduced using a range of YouTube and BBC videos from a David Attenborough series, after which the lead teacher led a discussion with the children about their observations of the habits and survival needs of the crabs, which were compared and contrasted to the students’ own needs. The children then used butcher’s paper to record a basic concept map summarising key learnings from the discussion, after which they brainstormed and sketched survival items and accessories they felt might be needed in the crabs’ tank.

While many sketches of items were produced, during the subsequent teacher-led discussion, they were sensitively challenged with respect to their suitability, encouraging the children to exercise critical and evaluative thinking regarding their ‘fitness for purpose’ (not all ideas were designed for the crabs’ needs). The introduction established the authenticity of the task, generating high levels of motivation and engagement by the students. Through subsequent processes of investigation and experimentation, students were able to 3D print objects for their class hermit crab (see Figure 3).

Figure 3 – 3D Printed Habitat for the Hermit Crabs
In their reflections, the three teachers described the early activities as a way of introducing the topic and preparing students for 3D design and printing in subsequent lessons. Noting the
enthusiasm among her students, Mackenzie regarded the arrival of the hermit crabs as “incredibly motivating”. The module also constituted an extended opportunity to develop the collaborative capabilities of students. Madalyn observed that although her students “struggle with collaboration a lot… it was great to have our students mixing with others from different classes”. Mackenzie similarly observed that “it was encouraging for me to see some of the students attempting to lead their activity and encouraging the other students in their group to talk about their ideas – learning together!” , while Timothy reflected that “students were very enthusiastic and excited to prepare the tank before the hermit crabs’ arrival [but] I saw a lot of students struggling to listen to each other’s ideas. It would be ideal to explicitly teach them how to share their ideas”.

**Learner Outcomes and Engagement**

Coding the 31 observed lessons according to the sorts of Student Learning (SL), Learner Engagement (LE), Task Designs (TD) and Teaching Approaches (TA) provided insights into the nature of the makerspace-based learning across the 24 classes. A summary of the coding results is shown in Table 3 below.

<table>
<thead>
<tr>
<th>Domain</th>
<th>Descriptors</th>
<th>Code</th>
<th>Frequency (n)</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Student Learning (SL)</strong></td>
<td>Demonstrated skills</td>
<td>Creativity</td>
<td>22</td>
<td>71.00%</td>
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<tr>
<td></td>
<td></td>
<td>Design Thinking</td>
<td>20</td>
<td>64.50%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Problem Solving</td>
<td>18</td>
<td>58.10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Critical Thinking</td>
<td>15</td>
<td>48.40%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Authentic Learning</td>
<td>11</td>
<td>35.50%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inquiry</td>
<td>5</td>
<td>16.10%</td>
</tr>
<tr>
<td><strong>Learner Engagement (LE)</strong></td>
<td>Observed learning behaviours</td>
<td>Engagement</td>
<td>31</td>
<td>100.00%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collaboration</td>
<td>14</td>
<td>45.20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Autonomy</td>
<td>12</td>
<td>38.70%</td>
</tr>
<tr>
<td><strong>Task Design (TD)</strong></td>
<td>Task design and types of making</td>
<td>Online (making with technology)</td>
<td>26</td>
<td>83.90%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Offline (making with physical materials)</td>
<td>17</td>
<td>54.80%</td>
</tr>
<tr>
<td><strong>Teaching Approaches (TA)</strong></td>
<td>Pedagogies, instructional methods, and strategies employed</td>
<td>Explicit Instructions</td>
<td>24</td>
<td>77.40%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Open-Ended Inquiry</td>
<td>17</td>
<td>54.80%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Problem-Based Learning</td>
<td>4</td>
<td>12.90%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Team teaching</td>
<td>4</td>
<td>12.90%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stations</td>
<td>4</td>
<td>12.90%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Project Based Learning</td>
<td>1</td>
<td>3.20%</td>
</tr>
</tbody>
</table>

The fact that students demonstrated creativity in 71% of the lessons that researchers observed reflects well on the cognitive potential of makerspace-based learning. The prevalence of design thinking in almost two-thirds of the observed classes likewise reflects the large degree to which students in a majority of classes were presented with design challenges or problems, and given latitude in the way they addressed these. Having problem solving occur in over half of the observed lessons and critical thinking in almost half of the lessons, demonstrates that makerspaces have the potential to address many of the thinking skills being targeted by 21st
Century curriculum. The fact that authentic learning and inquiry were observed in a minority of lessons was not necessarily a negative reflection on the teachers – only one lesson was observed for most teachers, so it is possible that those aspects of learning were integrated into other lessons.

Although the project encompassed digital design and 3D printing, many of the observed lessons involved both online and offline activities, or even fully-offline activities, as teachers attempted to develop their students’ tactile understanding of how the 2D screen-based design environment related to the 3D world for which students were creating their designs. To support learning in makerspaces, the majority of lessons observed involved explicit instruction and open-ended inquiry, providing students with both structured learning and the opportunity to experiment. Teachers across lessons were also observed to apply a range of teaching approaches relating to problem-based learning, workstations, team-teaching and project-based learning to enhance the learning outcomes of their students. Importantly, high levels of engagement were observed at least at some point across all 31 of the lessons observed. This was coupled with observations of both collaboration and learner autonomy in many of the lessons, once again capabilities being targeted by 21st century contemporary curricula.

**Students’ Perceptions of Learning in Makerspaces**

Data from the student paired interviews provided insights into how young children viewed the impact of makerspaces on learning outcomes and learner engagement. One recurring theme was that the makerspace activities challenged students to learn mathematical concepts relating to size, shape, proportion and transformation, because their on-screen designs needed to be scaled according to the physical world. Damien commented “when we build it, and then we print it out sometimes you don’t… sometimes it will be giant and sometimes it will be small so we don’t know whether it will be small or big.” With persistence, students were able to scale, size and place their creations appropriately, as Denise explained during her interview: “All of the things has [sic] to be the same size because if we don’t move it, it’s going to be like something like a blob. So we can move it properly. That’s why we have to have it the same size.”

Students were also able to develop their digital literacies, often in a way that related to their previous experiences and capabilities. As Coby explained, “in Blocker it was very easy because you just… It's like Minecraft and then I know how to play Minecraft very much. You just like build things. You build things so that's why it's very easy. On Toy Designer [Makers Empire tool] when you press the thing and… It will be there.” The creative possibilities afforded by the platform also provided a degree of challenge that students appeared to appreciate, as Leanne commented: “I like school better [now] because it’s difficult [with] the Maker’s Empire app, and I need to learn more about it”.

Students could also identify how what they were learning was authentic, often recognising practical future applications of 3D-printing. Denise commented, “we can design clothes in the Maker’s Empire and we can ask people, do you like these coloured clothes, and if they say yes, we can make the clothes. We can give them some choices, and we make them in the Maker’s Empire app. Then we can give them some choices by painting them, and if they see some one of them they like, you have to make it”. They were also able to relate what they were learning to future careers, and several students demonstrated ownership over their learning by independently designed 3D objects for use in their everyday world out of class time. This is
illustrated by a quote from Charlotte: “but I also would like to be a vet because like… and make them a home because we can use the app to make things to help animals, like a toy, and I made a like toy ball for my dog.”

Teacher Perceptions of Teaching in Makerspaces

Post-project teacher focus group data provided a further perspective on learning and teaching in makerspaces. Teachers identified several ways in which students benefited from learning in makerspace environments. For instance, Kirsten noted how the design process developed critical thinking and reflective capabilities:

I think the main thing my students got from it is they just learned to be really good, reflective learners. And critical in providing really… constructive feedback through the delivery-design process. You know, you have to provide that feedback to refine your level.

Several interesting issues were observed relating to the transfer of ideas between the technology-based design environment and the physical world. Jane commented “I found that their ideas were grandiose ideas. They were hard then to transfer onto the... You know, onto the app”.

Consequently, several teachers put in place pedagogical strategies to help students translate between the digital and physical world. As Abigail described, “we used Lego and wooden blocks for them to physically make it, so they could see ‘ah, my design looks like this’, [and think] well, how is that going to work?”.

Some teachers noted how the authentic problem-solving tasks had curriculum benefits, for instance, developing a deeper understanding of science. As Sophie observed:

So, it’s not just the creation, but it’s also the application of their design. In our case, it was for shadows in a flatter shape. And then looking into that: What makes a good shadow? So that’s what I mean. It really got us deeper into the science side of light.

The cross curricular nature of learning was also seen as an advantage by Jasmine, who remarked, “I really liked how it allowed me to sort of look at learning as a whole, right, not: ‘This is English, this is Maths…’. I could think about in what ways I could make it more meaningful, I could change it and relate it to all the KLA’s”. Links to literacy were often noted, such as when Amanda said, “they were able to describe in a lot of detail what they’d change and how they’d change it and why they changed it, which was really great”.

Two of the main issues that teachers identified were to do with resourcing and Internet connectivity. As Mackenzie commented, “our big problem is that the department’s Wi-Fi is very slow… And sometimes a whole session would pass and it still hadn’t logged in”. In terms of resourcing, teachers even felt one iPad between two students made teaching “a bit tricky”. Teachers also felt it would have been ideal to have one 3D printer in each room so that each class could see their models printing. While students enjoyed being able to print their models, the time taken to print was seen as an issue. Amanda noted:

My kids were most frustrated with the fact that it just takes so long to print. I think they thought they’d designed it, now I want to test it. But it’s actually quite a lot of waiting in this process.

However, they were so excited to have the printed object and to
test something that’s a physical thing that they could use.

One theme that emerged from several teachers’ comments was how the module benefited weaker ability or more reserved students in terms of increasing their engagement and confidence. For instance, Julia described “quite an introvert little boy, very quiet, he was the shining star” and related, “every day I see this little, timid little boy who is always been in the back of my mind with concerns. Now he’s the brave boy, you know, in the class”.

Teachers agreed that the makerspace project brought about several changes to their learning environment, whereby their classroom became more open and communal. Some teachers indicated that not only were students often benefiting from learning from one another, but also from seeing their teachers as fellow learners. In Jane’s words, “I think it’s nice for the kids to see us learning… and one of my girls said the other day, oh, you never stop learning all your life. And I thought, she’s seeing, it is a process she is seeing.” Moreover, the authentic design environment led to small on-demand groups of highly motivated learners, which offered a new dimension to the classroom for some teachers: “I gave them the option to come get that knowledge if they wanted to. And I found they were so engaged in that when I gave them the option…. I was like, whoa. This is the way to teach.”

Other themes that were observed included the high levels of engagement and enthusiasm, as well as increases to confidence in working with technology, collaborative skills, and resilience.

The importance of professional learning and experience

The importance of professional learning and support was evident from the study. Responses to the pre-professional learning questionnaire (0 = Strongly Disagree, 6 = Strongly Agree) suggested that teachers were lacking in “confidence to teach in makerspaces” (M=3.04, SD=1.16). In contrast, their post-professional learning responses indicated that they were much more confident (M=4.44, SD=0.8). Thus, the professional learning program enabled teachers to commence teaching their modules with significantly greater confidence, t(26) = 4.88, p < .001. This may have been due to the overall quality of the professional learning program, which teachers generally agreed was well designed (M=4.63, SD=1.25). Molly’s statement in the optional comment field of the post-professional learning questionnaire is reflective of her colleague’s high ratings: “the professional learning was an eye-opener, broadening my understanding of the ways makerspaces can be used to solve real-life problems”.

Teaching makerspace classes made a considerable contribution to teacher beliefs about makerspace-based learning and teaching. Pre-professional learning questionnaire responses were compared to post-implementation responses using the same 7-point scale, for items relating to importance of maker capabilities, identity as a maker, confidence to teach in makerspaces, and enthusiasm to teach in makerspaces. The results are shown in Table 4.

Table 4 – Paired t-test results for differences between pre-professional learning and post-implementation survey item scores
Table 4 shows that, as a result of the project, there was an increase in average survey response scores of participants for all four items, with three of the four mean differences being significant. In particular, teachers in the post-final questionnaire reported significantly higher levels of confidence (Item 2) teaching in makerspaces (M=5.0, SD=.62) than in the pre-questionnaire (M=3.04, SD=1.16), t(26)=7.29, with a large effect size, r=.82. Participants reported being significantly more enthusiastic (Item 3) in the post-final questionnaire (M=5.56, SD=.58) than was the case in the pre-questionnaire (M=5.22, SD=.75), t(26)=2.55, r=.45. Finally, the project had an impact on teacher’s identity, with participants reported identifying “as a maker” (Item 4) significantly more in the post-final questionnaire (M=5, SD=.73) than in the pre-questionnaire (M=4.07, SD=1.07), t(26)=4.22, with a medium effect size, r=.64.

**Discussion**

Learner outcomes and learner engagement were evident in all three cases presented. For Madalyn, Mackenzie and Timothy in Case 3, the use of the problem as a precursor to the design of objects for the hermit crab constituted an authentic, contextualised task. Students did not use the Makers Empire app in the lesson observed, which suggests that offline maker activities can still promote lateral thinking, creativity, critical thinking and problem-solving. In Case 2, the use of learning “stations” created variety, emphasising the value in both offline and online making, and compensated for the limited number of iPads in each of the classrooms. Although stations can be good for promoting variety, engagement and maker skills development, there was potential to more explicitly link station activities to the problems that are posed in makerspaces units of work. In Case 1, Emma, Sophie and Abigail were able to use a well-known children’s story to integrate curriculum areas, scaffold the design process, and produce authentic artefacts. In this case, narratives serve as scaffolding for designs that the students can bring to life with shadow puppetry, thereby promoting further creativity at the same time as learning about science concepts. However, an ongoing tension between structured activities and allowing students to undertake more open-ended autonomous inquiry was noted. The three cases represent but a small number of the pedagogical possibilities and complexities involved in transitioning to makerspace-based teaching.

The coding frequencies in Table 3 provide a characterisation of the sorts of learning that
occurred across the 31 observed lessons. Students were highly enthusiastic and engaged most – if not all – of the time, with frequent collaboration and student autonomy noted. Critical thinking, creativity, problem-solving and authentic learning were all evident in different ways, with creativity and problem-solving particularly prevalent. Teachers used a range of offline and online activities to develop their students’ capabilities, with teaching approaches including combinations of explicit instruction, open-ended inquiry, problem-based learning, team teaching, workstations, and project-based learning all observed. We conjecture that this is a more diverse range of pedagogical approaches than would typically be used in primary school classrooms, but further research would be required to substantiate this claim.

There were also evident relationships between the thinking skills of students and the teaching approaches that were used. For instance, learner autonomy was more common in lessons that utilised open-ended inquiry, while authentic learning often hinged on the problem that the teacher posed. The specific cases also provide pedagogical insights into relationships evident in Table 3. For instance, Case 3 exemplified how authentic open-ended inquiry was used to strengthen students’ knowledge of living things, and this kind of learning did not depend on the use of technology per se. Case 2 reinforced the value of allowing variety and choice in the lesson, providing students with more ways than one to build maker knowledge and skills. Case 1 pointed to an important creativity link between STEM disciplines and the humanities, showing how narratives can foster collaboration and creativity while giving students a goal towards which to work.

The students were overwhelmingly enthusiastic about the makerspaces modules. As an indication of this, the participating students in one school were asked by their teachers whether they would like to do another unit of work involving makerspaces in the future, and 242 out of the 249 students surveyed said yes (97%). The reason for this is probably best summarised by one student, Charlotte – “we love Makers Empire because we love being creative!” Based on the student interviews, the makerspaces modules also evidently developed children’s mathematical thinking and technological capabilities in a way that was authentic and enabled them to relate what they were doing to the world around them.

Possibly the greatest benefits and insights were derived from the post-project teacher focus group sessions, where the 24 teachers identified how the makerspace design and 3D printing activities helped to develop their students’ critical thinking, reflective thinking, authentic problem solving, technological and collaborative capabilities. Teaching in makerspaces enabled greater integration of different Key Learning Areas, and often more advanced performance in specific areas such as science and literacy. Important emotional and attitudinal gains in student confidence and resilience were also observed. However, teachers needed to have strategies to manage resourcing and technological issues.

For teachers to feel well prepared and confident to teach in makerspaces, it was important for them to undertake high quality professional learning in advance. Teacher post-project confidence and enthusiasm for teaching in makerspaces both increased significantly compared to their pre-project levels. Many teachers noticed how teaching in makerspaces had shifted their pedagogical approach to be more open, communal, collaborative, purposeful, contingent and dynamic. When the 24 classroom teachers who participated in the focus groups were asked whether they would like to teach another makerspaces unit of work in the future all 24 (100%) indicated that they would.
Conclusions and Future Directions

This study sought to characterise the nature of learning and teaching in makerspaces, using 3D design and printing technologies to enable their students’ learning. The findings show that makerspaces hold enormous potential in the early years of education to develop creativity, problem solving, critical thinking, design thinking and inquiry capabilities, in ways that could promote learner engagement, collaboration, and autonomy. A wide range of offline and online pedagogical approaches can be applied in makerspaces, including explicit instruction, open-ended inquiry, problem-based learning, team teaching, workstations, and project-based learning. Students in very early years of their schooling were able to successfully use the Makers Empire 3D design software and relate what they were doing to real-world applications. Teachers saw the benefits for students in terms of reflective learning, disciplinary understanding, cross-curricular integration, technological skills, collaborative capacities, resilience and confidence of their students, and many noticed how the makerspaces project shifted them towards more open, communal, purposeful and dynamic teaching.

Further analysis will be conducted on the data to determine: a) the precise aspects of the professional development that support teacher practice along with teacher needs; b) more in-depth understanding of cognitive aspects of learning in makerspaces and the role of the teacher, technology and tasks in supporting conceptual development; and c) greater phenomenological understanding of the reification processes involved in makerspaces and 3D printing and how those impact on student self-efficacy. While the findings of this study provide solid evidence regarding the efficacy of well-designed 3D printing and makerspace-based learning in the early primary school curriculum, future research is also required to investigate how the learning and approaches applied by teachers in this study can be propagated across wider regions, including school districts, regional and remote areas, and indeed entire systems.

References


Digital Literacy and Gen Z. The Unpacking of Expectations

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Introduction
Throughout history every generation has transitioned, and will continue to transition, from youth to adulthood shaped by their cultural generation construct. A construct that is developed from three influences; the life cycle effect, the period effect and the cohort effect and the interplay of these effects shapes generational and intra-generational nuances. These constructs are determined by age cohorts and are utilised to predict intergenerational differences in attitudes and behaviours. From an educational perspective cultural generational constructs require careful consideration as there is a risk of unintentional student stereotyping (Parry & Urwin, 2010).

The Western Cultural Generation Construct defines Generation Z (Gen Z), also referred to as iGen, @generation or the pluralist generation as being currently aged between 6 and 23 years old (Hampton & Keys, 2017). As with any generational cohort, the individuals who make up the Gen Z cohort are shaped by their experiences and influences. Gen Z refers to a culturally diverse population who do not remember life before the internet and are often referred to as the digital natives. They are a connected generation, constantly connected to the internet, their sophisticated digital devices and each other. According to Dalby, Figaro Digital, and Jaywing (2018) in the United Kingdom (UK) smartphones are the digital device of choice for 97% of 16-21 years olds and the average age UK youth receive their first smartphone is seven. The most recent data in New Zealand (NZ) is from 2016 and 81% of 10 year olds owned a mobile device and 91% of 18 year olds owned a smartphone. Gabel (2017) suggests that for Gen Z these devices “run as an appendage or extension of their very identity” (¶.7) as they are used to having access to information via an omnipresent personal digital device every minute of the day.

Discussion
Each generation has its own defining point in history. In 1995, at the birth start point for Gen Z, 21.7% of all NZ households owned a computer and one in five New Zealanders had heard of the internet. By 2011, when Gen Z had reached the age of 16, 98% of New Zealanders aged 12 to 29 used the internet on a daily basis (Brown, 2014). While Generation Y (Gen Y) immigrated to the digital media, Gen Z’s defining point is that they are the first generation in our history to be immersed in the digital culture. They do not have a pre-internet reference point. However, Gen Z is the not the first generation that has impacted by technological advancements, nor is it the only generation to have reference points unique to them. The Baby Boomers were the first generation to not have a reference point before wireless radio, for Generation X it was the television age and Gen Y did not know a time before IBM personal computers (McCrindle Research, 2012).

Current discussions occurring concerning the impact of technology on the cultural norms for Gen Z have not occurred in isolation. In 1985 when the oldest Gen Xer was 25 years old television viewing was linked to a movement away from cultural diversity toward cultural homogeneity. The findings of a series of surveys of traditional regional cultures in the United States found television viewing was contributing towards the creation of a geographical homogeneity of political and social views across these cultures (Morgan, 1986). In the 1990’s,
thirty years after the introduction of television a significant change to the social capital in American society was reported and it is proposed that this change which was directly attributed to television viewing (Brehm & Rahn, 1997; Putnam, 1995). In 2001 Wylie acknowledged television as part of the NZ cultural landscape and today television has been viewed as a vehicle to inform and educate and promote cultural revitalisation (Moriarty, 2009; W. G. Pearson & Knabe, 2015). As societies continue to evolve the impact of future technologies on future generations will continue to instigate research focused on cultural shifts. Generational change is inevitable, and critical discussion on the impact of this change is foreseeable.

One of the challenges evident for Gen Z today is the timing of the exponential rate of digital integration and the birth start point of Gen Z has resulted in a rapid change in the cultural norms (Leibler, 2018). This has created a position where age cohorts, even one generation apart, are significantly different and from this difference develops tension and the tension leads to a generation gap. Historically the cultural norms across two or three generations had a number of similarities and the differences across these generations had very little influence on their collective lifestyles. In terms of popular media the generation gap is often used to describe the broad differences between one generation and the next, and is regularly described as the navigating of the challenges between parents and their children (Fyers & Walters, 2017; A. Pearson, 2017). In the context of this article a sociologically approach is adopted and the generation gap is present when there are significant differences between generations that has been created by lifestyle and/or period effects.

In 2001 this generation gap was recognised in education at the time the first as Gen Z entered the school system (Prensky, 2001). Due to the rate at which digital integration has occurred the gap between Gen Z and previous generations is larger than other gap in our history (Leibler, 2018). In NZ at the age of 10 youth witnessed the birth of the smartphone followed by the first multi-touch computer tablet in 2010. The internet has become a fundamental part of their cultural paradigm and it is an integral part of who they are and influences how they function and live their lives (Lai & Hong, 2015). As a result of this integration Gen Z are viewed as digital natives. They are individuals who have been immersed in a digital culture and are not aware of a reality without the internet (Palfrey & Gasser, 2013; Prensky, 2001).

From this level of immersion Gen Z bring, and will continue to bring, an unprecedented level of technological savviness to their post school pathways. They are highly proficient with digital technologies in their current context. However, there is an unrealistic expectation that their current level of digital proficiency will be immediately adapted for their post school pathways with very little time required for orientation and integration. Digital proficiency is a transferable skill that adds value to any situation, but for the transition to be successful a contextually driven orientation is essential (Ashley, Brown, Halcomb, & Peters, 2017). For students transitioning into academia or employment post school pathways the success of their transition is determined by the processes that are implemented to acknowledge their current level of digital proficiency and to support their understanding and navigation of their new context.

In many instances there is a disconnect between the students subjective and objective perspectives of their post school pathways. In NZ the transition from secondary school to tertiary study is not always a successful experience as NZ has one of the lowest rates of tertiary qualification completion rates in the OECD due to under preparedness of students for the expectations of tertiary study (Speedy, 2016). Gen Z expects digital integration at tertiary level will be the same as their secondary school experiences (Kozinsky, 2017). They are accustomed
to omnipresent digital technology, and with this presence is the expectation digital services will always be available to them in all facets of their lives. This can create a challenge for educators as digital technologies are a fully integrated experience for Gen Z. They are a global generation and the avenues available for them to support their learning journey is limitless.

As each new generation transitions through their education journey the response, for educators, is to review and consider empirical evidence to guide practice. Care needs to be taken that during the consideration and implementation of this evidence that we are not participating in learner profiling. In the context of this article learner profiling occurs when education is considered from a homogenous perspective and learner assumptions are made by education providers on the basis of generational membership rather than a student-centred perspective. Costanza and Finkelstein (2015) argue generational differences are myths being purported by researchers and popular media and they are not situated in “solid” empirical evidence. They do acknowledge there is a wide range of evidence that is focused on explaining the differences however this evidence is without critical analysis of how the differences have occurred. Brink, Zondag, and Crenshaw (2015) agree with the position that when discussions and interventions are generational based there is a risk that groups of individuals being stereotyped. In 2005 William Straus reminded us we need to be respectful of generation nuances as “each generation brings something new and important to teaching and learning” (Straus, 2005, p.5).

Stereotypes are strategies that can enable us to make decisions quickly and efficiently. In terms of Gen Z their connectedness is visible and societies are wired to categorise the digital capabilities of Gen Z based on what we see (Brink et al., 2015). However the challenge is to move beyond the stereotype and the popular media hype with regard to their digital abilities and consistently maintain focus on the qualities and the abilities of the individual rather than group think. Each generation has brought a unique learning style to education. Gen Z live in a hyperlinked world and they are confident users of digital technologies, digital integrators and technologically literate but do they possess the level of digital currency tertiary educators expect (Wilhelm & Tedmon, 2018). More importantly, are the expectations based on the critical analysis of empirical evidence.

Summary
There is a generation gap for Gen Z as they transition into tertiary studies. The rapid integration of digital technologies in education has result in complexities for Gen Z that would not have been experience by their tertiary educators (Barber, Donnelly, Rizvi, & Summers, 2013; Lamar & Lodge, 2014). For Gen Z the digital environment is “like their mother tongue” (Cornu, 2011, p.2) and all other digital users, including Gen Y, have migrated to the digital platforms. As a result of this migration, not all digital users may not be completely fluent or cognisant with the digital environment. According to Prensky (2001) there is an accent evident in the way digital migrators utilise digital technologies and they lack the digital fluency of Gen Z. In terms of education this accent is a precursor for a generation gap (Prensky, 2001). Non-digital natives are teaching digital natives, educators are using a pre-digital language to educate a digital speakers (Cornu, 2011).

In education the language differences between educators and students are not a new phenomenon. Teaching practice, including language, has consistently evolved since the time of the ancient civilisations and will continue to evolve as education changes to meet the needs of the next generations. Educators and students are not a homogenous entity, they each bring to the education context their cultural capital, and their understanding of digital technologies and digital literacy. Emerging technologies are consistently changing the landscape and this
has an impact on our understanding of digital literacy. In terms of digital literacy and Gen Z, the unpacking of the expectations is complex and the interplay of their life cycle, period and the cohort effects will continue to contribute to the complexities.

References


