MATHEMATICS EXPERIENCES WITH DIGITAL GAMES: GENDER, GEOGRAPHIC LOCATION AND PREFERENCE

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Numerous digital games contain mathematics ideas and representations. This study investigated the game playing preference of 410 Australian students who classified the types of mathematics content and ideas present in digital games they played in out-of-school contexts. The results of the study revealed significant gender differences in the type of games primary-aged students played. Females tended to prefer playing games that required logic and problem solving while males preferred games that contained maps. Results also revealed an interaction effect between gender and geographic location. In each case, gender differences were more pronounced in non-metropolitan locations than metropolitan locations.

INTRODUCTION

The broad focus of this study was to determine the type of mathematical experiences students engage with in out-of-school settings. Of particular interest was participants' engagement with digital games that contained specific mathematics content or ideas. Our definition of mathematics content includes not only quantitative reasoning and literacies but also measurement ideas, graphical data and spatial reasoning. Elsewhere (e.g., Lowrie & Jorgenson, 2011), we argue that the mathematics concepts are contained within most digital games—with representations that include large numbers; algorithms; graphs which may show energy levels or similar measures; or games that display maps so that the gamer can locate objects and navigate through spaces. Increasingly these games have dual screens and multiple representations of maps and perspectives. As Wheatley and Brown (1997) posited, many aspects of mathematics are image-based and as a result, it is important to understand the effectiveness of new technologies on students' mathematical development as they spend increasing amounts of time with digital technologies. This study considered the mathematics content of the digital games students' play and the extent to which such engagement differed in metropolitan and non-metropolitan areas. Furthermore, the study considered potential differences between males and females' engagement *within* these contexts.

Diverse geographical contexts

Australia is a country which is both diverse culturally and geographically. The population of Australia is clustered around relatively large coastal cities, with very few large metropolitan cities located away from the coastal areas. The OECD Programme for International Student Assessment (PISA) results indicate that Australia scores in the top ten countries in numeracy. However, there is cause for concern as the

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Australian results demonstrate greater variability between the best- and worst-performing students than other high-performing countries. Some of the most at-risk students are those who live in rural/remote areas (37% below those students living in metropolitan areas) (MCEETYA, 2005). It is not that these learners are cognitively inferior but due to their life circumstances, the opportunities to immerse themselves in a numerate culture are very limited. Moreover, for these students, issues of culture and language compound their access to the discourses of school mathematics (Sullivan, Zevenbergen, & Mousley, 2005). Unlike their urban counterparts whose worlds are saturated with mathematical constructs—transport timetables, street directories, signage, advertising and so on, students who live in geographically remote areas have less exposure to these signifiers and hence many of the taken-for-granted aspects of school mathematics are very restricted in their lifeworlds (Lowrie, 2007).

Gender and digital game play

Since the investigation involved students playing with digital technologies it was also timely to consider the role gender played in such engagement—given the extensive literature base which points to differences in how males and females engage with games (Bananno & Kommers, 2005; Brumbaugh, 2009) and the types of games they prefer to play (Cassell & Jenkins, 1998; Lowrie & Jorgensen, 2011). With respect to the type of games student play, studies have focussed on game genre and male preference for particular types of games—for example, games that simulate violent acts (Jansz, 2005) or games which require a competitive mindset (Hartmann & Klimmit, 2006). On the other hand, there is evidence to suggest that females prefer playing games that involve logic (Quaiser-Pohl, Geiser, & Lehmann, 2006) and games which promote skills such as perceptual speed and time skills (Ziemek, 2006).

Of particular interest to mathematics educators, is the fact that males prefer games which are graphically sophisticated and require good spatial awareness and visualisation skills (Lowrie & Jorgensen, 2011). This point is noteworthy since males tend to outperform females on mathematics tasks which require high spatial reasoning (e.g., tasks which require the interpretation of number lines and maps, see Lowrie, Diezmann, & Logan, 2009).

The present study goes beyond previous research by investigating the actual mathematics content contained within digital games rather than the types of games student play. Moreover, we take note of Fennema and Leder's (1993) challenge to ensure that studies that consider gender differences in mathematics are focused and strategic. This is achieved by specifically asking the students about the mathematics in the games they play—and thus focuses on the students' perceptions—rather than what the games designers stipulate the game constitutes.

METHOD

The project focused on the development and subsequent implementation of a Digital Landscape survey with primary school students. Data from the survey were analysed to

address the three research questions of the study using the Statistical Package for the Social Sciences (SPSS for Windows 17.1). The broad aim of the study was to determine the nature of student engagement with entertainment-based digital games with specific reference to mathematics content. Two research questions were formulated:

1. *Are there gender differences in students' engagement with digital games?*
2. *Are there geographic-location differences in students' engagement with digital games?*

Participants

The participants comprised 410 students (M=195; F=215) from two geographically-distinct locations (Metropolitan=171 and Non-Metropolitan=239) in Australia. The metropolitan location was one of Australia's largest coastal cities while the non-metropolitan location was a regional inland city. The populations of the two sites were distinctly different. The sample was purposively selected from a general expression of "participation interest" from schools in both catholic education and state systems. The participants were aged 10–12 years from Grades 5 and 6. The questionnaire was administered to all Grade 5 and 6 students at the respective schools, with students completing the questionnaire at home once parental consent had been received.

Survey instrument

The survey was designed to describe the nature of student use of a range of entertainment-based digital games with specific reference to mathematics content. The survey sought information that would provide patterns of student behaviour in relation to preference for the content and processes involved in playing the games. The survey used in this study was based on the British Educational Technologies and Communications Agency (BECTA) (2002) questionnaire on Young People's Use of ICT and adapted specifically for this study. Further information regarding survey validity is described elsewhere (see Lowrie & Jorgensen, 2011). The present study focuses on the items which asked students to provide information about the presence of mathematics content contained within their game-playing. These questions were in a 5-point Likert scale (in the form *frequently* through to *never*) format. Descriptive data were also collated and included students' gender, grade level and favourite game. The four survey questions appear in the Appendix.

RESULTS

Comparisons of digital game play

The two research questions were investigated through an analysis of the participants' responses to four items from the survey. These items (the independent variables) included questions regarding algorithms, maps, graphs and problem solving (see Appendix). A multivariate analysis of variance (MANOVA) was used to analyse mean

scores across Gender and Geographic location dependent variables. The MANOVA revealed statistically significant differences between the mean scores of students across the *Gender* [F(4,403=13.2, p<.01] variable. There was no statistically significant difference on the *Geographic location* [F(4,403=2.19, p>.05] variable. Noteworthy, there was statistically significant interaction (*Gender* x *Geographic location)* [F(4,403=6.59, p<.01]. Table 1 presents the means (and standard deviations) for gender and geographic location across the four questions.

Location	Gender	Algorithms	Maps	Graphs	P. solving
Metro	M (n=84)	2.42	2.81	2.27	2.36
		(1.2)	*1.3*	*1.2*	*1.4*
	F (n=87)	2.45	2.21	2.15	2.45
		1.1	*1.2*	*1.0*	*1.2*
Non-Met	M (n=111)	2.18	3.12	1.79	1.69
		1.1	*1.4*	*1.1*	*0.9*
	F (n=128)	2.68	2.20	2.18	2.64
		1.1	*1.1*	*1.0*	*1.4*

Table 1: Means (*Standard Deviations*) of Student Scores by Grade and Gender

Subsequent post-hoc analysis was conducted to determine where differences across the Gender variable lie. ANOVA's revealed statistically significant differences in game playing preference on *map content* [F(1, 410=24.13, p<.001] and *problem solving processes* [F(1, 410=17.78, p<.001] variables. Males ($\bar{x}$=2.97) were more likely to play games containing map content than females ($\bar{x}$=2.21). By contrast, females ($\bar{x}$=2.55) were more likely to play games involving problem solving than males ($\bar{x}$=2.03).

With respect to interaction differences, there were three statistically significant differences including *map content* [F(1, 410=6.14, p<.01], *graph content* [F(1, 410=5.65, p<.01] and *problem solving processes* [F(1, 410=12.08, p<.001]. Figure 1 displays the interaction between males and females across geographic locations for these three questions. In each of the three instances, the interaction was due to there being smaller gender differences at the metropolitan site than was the case at the non-metropolitan site.

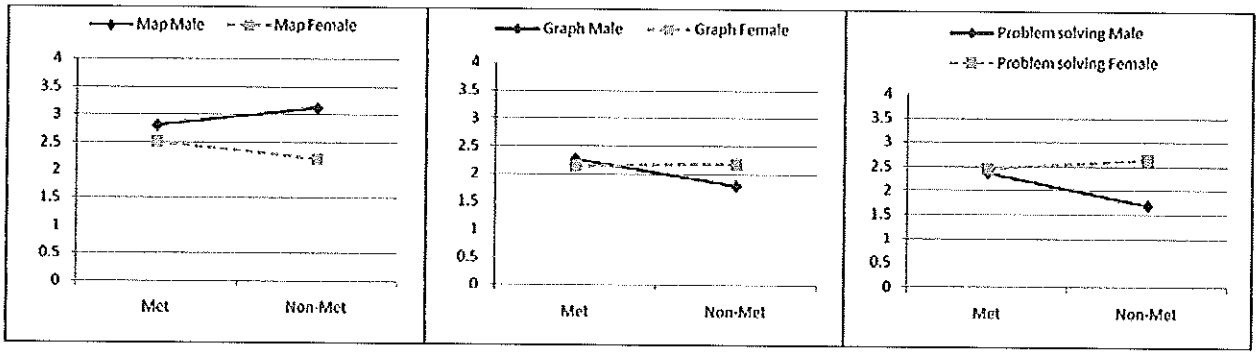

Figure 1. Interaction between gender and geographic location for *map content, graph content* and *problem solving processes.*

Game playing preferences

The questionnaire also provided opportunities for the students to describe the types of games that they preferred to play. These data were collated and categorised by gender and location. The analysis below provides a description of examples of games identified through the descriptive data as being played by non-metropolitan males and females in order to illustrate the interaction effects described above. That is, the identification of the different types of games non-metropolitan males and females played which elicited responses indicating the mathematics content they perceived to be accessing whilst engaged in gameplay. The intent of this analysis was to describe features contained within these games and the explicit mathematics concepts identified. Figure 2 features a game (*Runescape*) that non-metropolitan males frequently played involving map content and concepts. Figures 3 and 4 represent games commonly played by non-metropolitan females which contained graph concepts (*Nintendogs*) and problem solving (*Club penguin*).

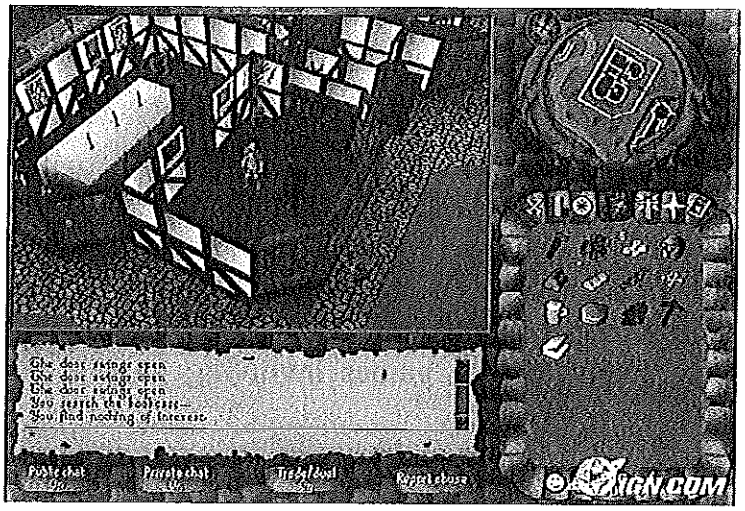

Figure 2. A preferred game of non-metropolitan males with mapping content

The game Runescape was a favourite among males. This game, and others of this genre, typically provides mapping content with multiple map perspectives. The perspective on the left side of the screen is approximately at 45°. This screen is utilised to move between rooms and navigate the immediate environment. The text below the representation provides information concerning the location and movement of objects within the immediate space. The map on the top right is a birds-eye-view perspective of a region much larger (and less detailed) than that of the left side. This map is used as a location device and provides positioning information in relation to the larger 'world'.

In Figure 3, the Nintendogs game, generally played by females, displays two of the four screens with graph information. The top left frame contains a form of picture graph represented with images and numeric symbols. The top right frame contains a visually complex bar graph which represents information on a percentage scale. The data in these frames are related and provide information pertinent to the game.

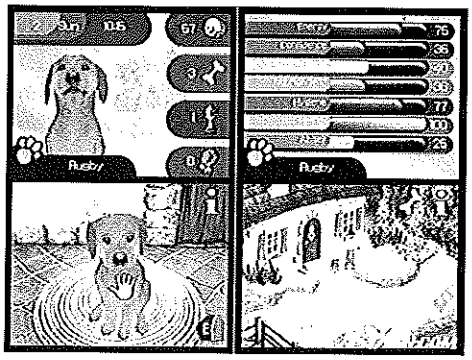

Figure 3. A preferred game of non-metropolitan females using graphs

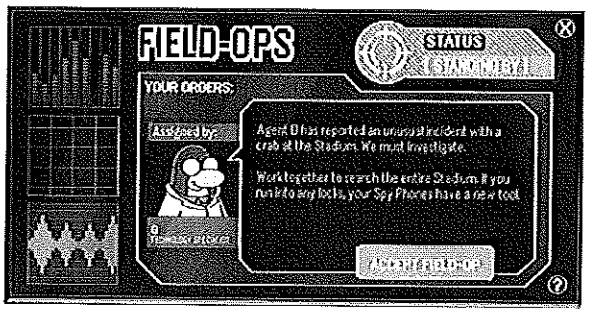

Figure 4. A non-metropolitan female preferred game with problem solving.

Figure 4 (Club penguin) is an example of a game involving problem solving in which there is a scenario that needs to be solved. The textual information requires the gamer to investigate an incident at the Stadium by searching the entire location with a clue "if you run into any locks, your Spy Phones have a new tool". These new tools are utilised to solve several tasks in order to achieve an overall objective. These scenarios are often described as challenges or components of a 'staged' and sequenced set of problems that need to be completed to achieve a main goal. Females were much more inclined to play this game, and others within this genre, than the males.

DISCUSSION AND CONCLUSIONS

Our study examined the nature of student engagement with entertainment-based digital games with specific reference to mathematics content. There were gender differences for two of the four variables; namely, *map content* (in favour of males) and *problem solving processes* (in favour of females). There were no statistically significant differences in students' digital game engagement across geographic location. There was, however, an interaction effect between gender and geographic location across the *map content*, *graph content* and *problem solving processes* variables.

The gender differences identify the type of mathematics content that males and females prefer to engage with. One explanation for males' preference for digital games that contain maps could be associated with the general assumption that they prefer games which are graphically sophisticated and often involve competitive traits (Hartmann & Klimmit, 2006; Zevenbergen, 2007). Other studies (e.g., Lowrie & Diezmann, 2011; Lowrie & Diezmann, 2007) have shown that boys outperform girls on mathematics items that require the decoding of spatial information—and particularly tasks that required the interpretation of map-based graphics. By contrast, females prefer playing games that required problem solving and scaffolded challenges that involve logic (Lucas & Sherry, 2004; Quaiser-Pohl et al, 2006).

Although there is a generally accepted view that non-metropolitan students are disadvantaged in terms technology engagement and opportunity—due in part to

isolation and a range of factors associated with the digital divide (Gee, 2007)—the results of this study did not find differences in student engagement across location. This finding is noteworthy considering previous research on geographic location identified differences in the performance of primary aged students from metropolitan and non-metropolitan locations on map items that required interpretation of coordinate maps and landmark maps in favour of metropolitan students (Lowrie, Diezmann & Logan, 2011).

The results of the study reveal three consistent interaction patterns between gender and geographic location of the students. Males at the non-metropolitan location engaged with a higher number of map content games than males in the metropolitan area. By contrast, females in the metropolitan area were more likely to engage with these games. This interaction pattern was reversed for students' engagement with problem solving games. With respect to the graph content, males at the non-metropolitan location were less likely to engage with these games compared with that of the metropolitan males—while females reported that they engaged with similar numbers of graph content games irrespective of location. For the problem solving, there was a slight increase in the number of non-metropolitan females playing such games, whereas there was a dramatic reduction in non-metropolitan males playing such games.

Importantly, the majority of the games *all* of the students played—irrespective of gender or location—contained rich visual environments. These visual environments, due in part to advances in technology, where often dynamic and required high levels of visual reasoning in order to process varied forms of information. Most of the games played by these students contained maps (generally games they preferred to play) or graphs (especially non-metropolitan girls) that were more diverse and sophisticated than those they would typically encounter in school curricula, and these digital representations were also quite different to the static forms displayed in text books and work samples. We argue that is it time to utilise such digitally-rich (and dynamic) representations of maps and graphs in classrooms.

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