This investigation describes the way in which a case study participant (aged 7) used maps (including large- and small-scale maps, dynamic and static maps) to solve problems in a technology game-based context. The participant demonstrated the capacity to decipher graphical information when simultaneously moving between maps with different representations, orientations, perspectives and scales as he played a Pokemon Game Boy. It is argued that the authentic nature of the problem-solving context allowed the participant to meet a range of numeracy demands that were far more complex and sophisticated than the type of mathematics he experienced in school.
Problem solving in out-of-school settings: Children “playing” in ICT contexts

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It is generally accepted that the most influential connection for early mathematics development is between the intuitive mathematics that students have learned through personal experiences and the mathematics they are exposed to in school contexts (Clements & Sarama, 2000). As mathematics becomes more abstract the relationship between school and out-of-school mathematics tends to become less tangible. Moreover, the connections between students’ everyday and classroom mathematics are not always accessible when the contexts differ significantly (Clancy & Lowrie, 2002; Lave, 1998). For some time, educationists have attempted to challenge students to make connections between the mathematics they study in school and the mathematics they will encounter in life-like contexts—in some cases to justify and reinforce the importance of the school-based content.
Increasingly, there is a view that school mathematics should be concentrated around authentic tasks that provide opportunities for students to develop skills in knowing when and how to use mathematical knowledge for representing and solving problems in both practical and realistic situations. Lesh and Harel (2003), for example, maintained that the kind of problem-solving situations that should be emphasised are simulations of real-life experiences where mathematical thinking is useful in the everyday lives of the student or their family and friends. In recent years there has been a view that conditions that make out-of-school learning so effective must be recreated in classroom activities by “creating classroom situations that promote learning processes closer to those arising from out-of-school mathematics processes” (Bonotto, 2002, p. 3). Such an analogy creates a directional shift in terms of the mathematics content and processes that could be presented in classroom situations. Irrespective of whether or not the mathematical understandings are applied to out-of-school contexts or adapted from these realistic contexts, it is imperative that researchers and teachers: 1) develop a more comprehensive understanding of the processes students employ to solve problems in these out-of-school contexts; and 2) appreciate how mathematics studied at school is accessed and utilised in the student’s world beyond school.

Although the mathematics young children employ in these different contexts differ considerably, there are even greater distinctions between the technology children are exposed to at school and the technology they regularly use at home (Lowrie, 2002a; Mayer, Schustack, & Blanton, 1999). Although it is acknowledged that technology is essential in teaching and learning mathematics (NCTM, 2000) it must be recognised that advances in technology are creating an increasingly large gulf between the Information and Communication Technology (ICT) activities children are exposed to in school and out-of-school settings (Lowrie, 2002b; Yelland, 2001). Consequently, recent studies have exposed
children to technology not commonly found in schools (Mayer, et.al 1999; Clancy & Lowrie, 2002) in order to keep abreast with the influence these “advanced’ technologies have on student performance. Interestingly, these distinctions go beyond differences in the technological demands that are placed on students in the different settings. Clancy and Lowrie (2003) argued that some of the games children play at home require more sophisticated numeracy and literacy skills and understandings than would normally be expected of these children in classroom-based investigations.

The Context of the Study

The Pokemon phenomenon, which this study uses for its focus on children engaging in out-of-school ICT-rich contexts, consists of a range of different synergistic texts such as movies, videos, books, internet cheat sites, card games, computer games, board games and hand held Game Boys. To be able to use these texts effectively players use a range of literacies—such as linguistic, visual, spatial, auditory and gestural—to gather information across different text forms in order to become proficient at the games they enjoy playing. As Sefton-Green (2004, p. 162-163) maintained, Pokemon uses a greater variety of pedagogical techniques than schools and “makes no artificial distinction between literacy and numeracy demands. It is pluralistic in its mixtures of pedagogies, requiring rote learning and repetition as well as higher-order thinking”. In fact, it is relative easy to underestimate the amount and complexity of the knowledge that is required to solve problems in this context. In a similar vein, Buckingham and Sefton-Green (2004, p. 22) observed “the guidebooks and the websites that support Pokemon players are immensely detailed and quite incomprehensible to outsiders. [There are] some significant challenges in terms of finding, processing, remembering, and applying information. In interpersonal terms, this level of complexity also provides Pokemon enthusiasts with a great deal to talk about.”
In particular, these activities require participants to interpret large amounts of mapping-related information, explore relationships between 2D-3D representations and make sense of numeracy understandings across various multimodal forms. Moreover, the participants are required to employ a range of problem-solving skills to access information from these texts and apply knowledge to various novel and open-ended situations. It is proposed that the skills developed by the participants in these settings, primarily of their own accord, match the kinds of mathematics required in an information technology age. It is argued that educators should be encouraged to make closer connections to these forms of learning in order to make learning increasingly meaningful and authentic.

The interactive nature of the game playing allows participants to move in and out of different worlds—which tend to be represented in different ways. They are able to make connections between themselves in the “real world” and their persona within the game context. In developing these personas the players establish quite sophisticated links between worlds. The participants make meaning and establish scenarios that become both realistic and authentic. The authenticity of the journey is not solely created by a magnified power—it is embedded in the concrete artefacts that surround the Pokemon world. The artefacts include the television show, the playing cards and the cheat sites. As Sefton-Green (2004) argued, players learn to accept the rules and structures that actually break the spell of fantasy but often create explanations for events that make far more intuitive sense. It seems to be the case that players “derive these rules either from [their] understanding of social behaviour or from [their] explanation that characters in the game should behave in accordance with the genres in which they are embedded (Sefton-Green, 2004, p. 161).
The genres are established through the variety and richness of the Pokemon phenomenon. Cleverly, the artefacts are explicitly lined to the Gameboy experience. Moreover, it could be argued that these artefacts become truly authentic when they “reflect a genuine thirst for learning of the kind that engages one’s identity on a meaningful trajectory and affords some ownership of meaning” (Wenger, 1998, p. 270). Sfard (2002, p. 354) asserted that artefacts we use as discourse mediators are much more than “aids of thought”—they are though enablers and generators and are inseparable from the thought just like our physical actions are inseparable from our own body and the tools we use. The present study investigates the extent to which a case study participant used maps to support his engagement within the game context and monitors the influence these maps have on his problem solving.

The Approach

This investigation uses an ‘instrumental case study’ (Stake, 2000) which is a technique that can be used to advance the understanding of an external interest. In this case the participant was chosen because he was able to give the researchers access to the discursive practices of the Pokemon phenomenon and to illuminate his understandings about the numeracies and literacies needed for young players to successfully engage with Pokemon texts. Through using such a case study analysis the researcher is able to theorise the numeracy practices of the participant in relation to examples of the complex multimodal texts that are becoming part of his everyday context.

The Participant

The case study participant (aged 7) had been given a Gameboy (the hand held entertainment game) as a Christmas gift. Despite the fact that he had only been actively involved in most aspects of the Pokemon phenomenon for less than four months, Morgan already completed
the game on two occasions. Although Morgan’s access to the game was restricted to weekend activity he had been able to discuss the game and comment on the role supportive artefacts played in his understanding of the game in a relatively sophisticated manner. He demonstrated the capacity to access these additional texts and possessed a deep knowledge of the extent to which these texts related to each other. Morgan appeared to have invested emotionally in the Pokemon experience. Not only did he demonstrate a passion for playing the game, he valued the knowledge and skills he had developed as part of the experience. It was evident that Pokemon was having a significant impact on a range of Morgan’s literacies and numeracies. In fact, his mother had noticed that his reading had improved dramatically over this period of time. She reasoned that this began to occur when he read and thought about his literature-based texts in ways that allowed him to talk about the context (like he did while playing the game). Although he did not require validation beyond the motivation of the game itself he certainly enjoyed sharing his experiences with his younger sister and helping her when she required support.

The data were collected in naturalistic settings with the participant interviewed as he played the game. Audio-taped recordings were analysed with follow-up questions posed in order to clarify the student’s ideas and thinking processes. The researcher did a search of the internet cheat sites and studied the hand books in order to gain insights into the various forms of text used by the participants to play the game.

The Game

One of the key aspects of playing the Pokemon Game Boy is the notion of journey. Each game involves having a mission which involves going on a Pokemon journey in order to collect different species of Pokemon. These journeys require the players to move across a range of landscapes. Over time the game continues to evolve and so players constantly need
to seek out information from the different forms of text. For example, as the game moved to the gold and silver versions the world of Pokemon grew to include The Western Territories, just west of Pallet Town (which is already known from the previous levels). This is Johto League territory, where players have to use their previous mapping knowledge to get started in the new territory. As well there is information particular to specific places on the maps. Bloomingvale is well known for the Sunflora Pokemon, the people of Cherrygrove do not like their wild Quagsire being caught by trainers, while Charicific Valley is where you find the wild Charizard. Students need to know where to go, how to get there and what they will encounter, so they can be prepared, or, if they are after specific Pokemon then they know where they can go to look for them.

From a theoretical perspective, it seems to be the case that engagement within the Pokemon phenomenon can be viewed in terms of Wenger’s (1998) induction into a community of practice in the sense that there is a dynamic relationship between structure, agency and identity. Since Pokemon is constructed around the notion of a journey, the Gameboy is able to blur the boundaries between age, gender and culture. And as Sefton-Green (2004) argued, those players who have access to the internet also transcend the limitations of geography. Game players have access to a variety of maps to support their endeavour to catch Pokemon.

The Pokenav (see Figure 1) provides access to important information about the location of cities and pathways (Routes) that are recommended for travel from one city to another. Morgan accessed additional information about specific pathways from the Pokemon books. In these magazines Morgan encountered different graphical representations of cities—including maps with different scale, orientation and perspective.
Figure 1: A visual representation of the map illustrated in the Pokenav

**Case Study Analysis: Connections between Maps**

As the participant played the game he was encouraged to describe his journey through an explanation of the strategies he employed to “catch” Pokemon. Morgan was encouraged to describe the influence resource-based maps (including maps that were represented in directional, diagrammatical and pictorial forms) had on his capacity to locate Pokemon. Moreover, he was challenged to describe how his personalised mental maps (usually in the mind’s eye) were accessed to solve problems within the game context.

By offering players dynamic ways of interacting with maps these games enable players to refine their present knowledge and to develop a range of new and different ways of making meanings from their use of maps, and as a consequence increase the sophistication of their mathematical understandings.
Accessing and Using Maps

The participant used a number of maps to gain access to important information from the Pokemon world. These maps included “full” maps that represented the entire Poke-world (see Figure 1) and more detailed “zoom” maps that allow the player to navigate his way through towns (see Figure 2), cities, and various natural environments (including caves, mud slides and waterfalls) between these cities and towns. In addition, less detailed positional maps (see Figure 3) were regularly analysed in order for Morgan to determine where he was positioned in relation to significant landmarks.

Essentially, the maps were utilised to locate information that was necessary to find (or catch) Pokemon. Morgan’s capacity to reason visually and locate information in a relatively sophisticated manner was required in order to solve both routine and open-ended problems within the game context.
map], then you go across here and follow that thing [a pathway], you end up in Mountain Falls. That’s where the Magna Team are. You need to battle the leader two times.

Interviewer Has it been a while since you have been there..?

Morgan Yep. And I’ve got short memory.

Interviewer [Laugh]. I don’t know about that, you have good memory

Interviewer That’s the full view, the whole map, and when you are playing you go through bits at a time do you?

Morgan Yep. And this is Everyday City right over here. That’s the whole thing. I need to go over there, that’s the Pokemon Centre right over there.

(Morgan is referring to the Pokenav that shows the whole Houen area map and the individual cities that are colour coded to represent different buildings)

Interviewer How do you know the difference between each building?

Morgan Look down here (Morgan pointing to the symbol key on the Pokenav)

The Pokenav (see Figure 1) provides access to important information about the location of cities and pathways (routes) that are recommended for travel from one city to another. Morgan accessed additional information about specific pathways from the Pokemon books. In these magazines Morgan encountered different graphical representations of cities—including maps with different scale, orientation and perspective (see Figure 4).

### HM & TM Reference List

<table>
<thead>
<tr>
<th>HM</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>HM01 - Cut</td>
<td>House next to Rustboro City's Pokemon Centre</td>
</tr>
<tr>
<td>HM02 - Fly</td>
<td>Received from rival at Route 119</td>
</tr>
<tr>
<td>HM03 - Surf</td>
<td>House next to Petalburg City Gym</td>
</tr>
<tr>
<td>HM04 - Strength</td>
<td>Rusturf Tunnel</td>
</tr>
<tr>
<td>HM05 - Flash</td>
<td>Granite Cave (From Hiker)</td>
</tr>
<tr>
<td>HM06 - Rock Smash</td>
<td>Mauville City</td>
</tr>
<tr>
<td>HM07 - Waterfall</td>
<td>Groudon/Kyogre Lair</td>
</tr>
<tr>
<td>HM08 - Dive</td>
<td>Mossdeep City (Steven’s House)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TM</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM01 - Focus Punch</td>
<td>Route 115</td>
</tr>
<tr>
<td>TM02 - Dragon Claw</td>
<td>Meteor Falls</td>
</tr>
<tr>
<td>TM03 - Water Pulse</td>
<td>Prize of Sootopolis City Gym (8th Gym)</td>
</tr>
<tr>
<td>TM04 - Calm Wind</td>
<td>Prize of Mossdeep City Gym (7th Gym)</td>
</tr>
<tr>
<td>TM05 - Roar</td>
<td>Route 116</td>
</tr>
<tr>
<td>TM06 - Toxic</td>
<td>Fiery Path</td>
</tr>
<tr>
<td>TM07 - Hail</td>
<td>Shoal Cave</td>
</tr>
</tbody>
</table>

Figure 4: A partial map of HM and TM reference list accessed in Pokemon magazine
Although the magazine maps were more detailed (and in a larger scale) than the corresponding graphical representations in the Gameboy, Morgan found it advantageous to cross reference information whilst playing the game. The magazines became an important reference point for travel between cities because these maps provided more information within a single frame—not only was the scale easier to interpret, more information was represented within the given space. The Gameboy screen is relatively small (7 cm x 4 cm) and as a consequence the player would need to use scroll buttons (across eight compass-point directions) to view the information that could be represented in the magazine maps. Within the game-play context the player is able to navigate through space in both “full” and “zoom” modes (represented in Figures 1 and 3). The zoom mode displays information in a more detailed manner (possibly magnified ten fold) than the map that represents the Houen City. Morgan simultaneously moved between these two perspectives while regularly referring to the maps in the magazine.

Interviewer  So how many maps have you got on the screen at the moment?
Morgan  Two…The little map that shows you half of the town. You have to move over and it shows you the other half
Interviewer  So that’s ok to read, looking at half a town? Do you understand that?
Morgan  Yep, because you can still add it because the route becomes the other, it’s just the other part of the city.
Interviewer  Ok, so you can remember what the other half of the city is like?
Morgan  Yep…You flip backwards and forwards between the cities.

Morgan had developed an awareness of scale and proportion. Moreover, he appreciated the fact that you could only see part of the map in the zoom function mode and realised that one
part of the map was connected to the other even though both parts of the map were not visible on the single screen.

*Locating Information through Coordinate and Grid Referencing*

The Pokemon magazines provided Morgan with detailed information about the whereabouts of specific characteristics or attributes that could make the Pokemon “stronger” and more likely to win battles. This information was displayed through coordinate grid references (see Figure 4) which indicated where these specific powers were located within towns or cities. Morgan’s navigation through the game was regularly influenced by his decision to match particular Pokemon with specific attributes. He would determine which attributes (powers) his Pokemon required to effectively battle other Pokemon and would then make decisions about the paths he would take in order to locate relevant towns or cities.

Morgan
I use that *(referring to magazine)* for two reasons. I use that to find Pokemon, to tell me where Pokemon are and my HM1 and TM list which is right up the back *(Morgan refers to the list like the one represented in Figure 4)*

So I’ve got all the HM’s that you get in different places

Morgan
Like here, I know where Route 119 is, you get along there. You actually battle on your friend May for the third time. If you win she gives you fly, the HM move. Then you go up to the city and battle the gym leader, then you can use fly [an attribute that allows you to take your trainer to islands].

[This is] Harbour City. That’s the third town you will be in. Say I started at my home right down here, Little Route City, then I have to work my way up there. Then I have to battle May, my friend the first time there, then come back down to there to the Professors house and he’ll give me a Pokedex and then I will be able to go up to the city again and go across and battle the trainers and I will end up here. You get surf…I will just fly to it and show you how.

Impressively, Morgan not only remembered the directional sequences when revisiting cities, he was able to explain why it was important to go back to these destinations. His conversations referenced the Gameboy, the magazines and the Pokedex within the Gameboy

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1 HM’s and TM’s are specific moves that are used in battle when Pokemon confront each other. The main distinction between these moves is associated with the fact that TM’s can only be used in battle whereas HM’s (fly, surf) can additionally be used to take a trainer (the player) from one location to another.
simultaneously. Moreover, Morgan was able to effortlessly move between several graphical representations when describing his movements “inside” and “outside” the game context.

Interviewer: Can you explain why two maps of the same town are different?

Morgan: ...the big one shows you just where the towns are. Like if they are going longways, tallways, diagonals or circles.

Interviewer: Right, what does the big map look like?

Morgan: It shows you the world, like here the world and here are the little towns and here's the other one and there are little ones here (referring to the maps on his Pokenav)

Interviewer: Ok, and then you zoom in.

Morgan: There’s actually three maps... Because when you go on like if you click anywhere and go small, so you just see one more part and if you click say again, it just shows the whole world and then the little one

Morgan: So it shows you one little square, it can show you the whole world and it can show you how cities are.

He was able to appreciate that his (the trainer’s) location within a city or town could be represented in different ways on the same screen (as in Figure 3). Although he had not encountered notions of scale, proportion or perspective (in a school context) he was able to conceptualise the relationship between landmarks in different spaces as a series of routes. Furthermore, he was able to integrate these routes into networks of landmarks in ways that allowed him to make approximations of relative distances, and thus constitute a form of scale (Lehrer & Pritchard, 2002).

**Authenticity with the Game**

Many Pokemon artefacts (including maps) are highly concerned with representation of learning and their subject is often the acquisition of knowledge (Sefton-Green, 2001). Morgan was highly motivated by the Pokemon experience and had developed a real passion for learning. He was immersed in a world that gave him the freedom to make decisions and
become responsible for his own learning. Turner (1991) maintained that travellers are provided with the spatial and social freedom to exist in a space where they are not governed by their normal constraints. The maps certainly provided flexibility and established a degree of authenticity that reinforced his personal decision making.

Morgan (looks up the Pokenav) That’s the whole world, the whole thing. There’s different Pokemon in different places.
Say if I was there and I got lost in here. I go to Pokenav and find where I am and then I know I’ve been to that place and know I haven’t been to that place, so I just know which way to go then.
Morgan I haven’t been stuck yet. When I lose a battle I actually go back to the city you’ve been in front of the Pokemon Centre then you go back…to that city to where you were.

The opportunities offered through the game context allowed Morgan to form an interactive and dynamic relationship between the game and the maps he was accessing. He was able to use dynamic imagery (see Lowrie & Clancy, 2003; Presmeg, 1986) to make connections to various maps and his own problem posing. He developed internal narratives that became an integral component of the further external narratives that are developed when players engage with each other in talk beyond the game. Furthermore, it allowed him became an “insider” within the game context—allowing his persona to move dynamically within the game context while also considering space outside the observable boundaries of the game.

Conclusion

Morgan encountered several types of maps as he solved problems within the game context. The graphical information that needed to be deciphered and interpreted was much more sophisticated than the numeracy demands placed on him at school. The authenticity of these maps allowed him to become immersed in the game’s surroundings and personalise the game-playing experience in ways that school curricula did not seem to offer. Morgan commented on diving into the water, passing through a waterfall or moving through long grass. These “inside space” maps magnified the game experience to an extent where Morgan
felt that he was in control of his learning and consequently remained highly motivated to solve problems as part of the game context.

Interestingly, Sefton-Green (2004) argued that the Pokemon game presents a series of detours and alternate goals that can readily be accomplished which consequently tend to mask the game being played against a clock (and consequently in a linear sequence). Since players can wander around the Poke-world and still collect creatures and prizes, there is a sense of accomplishment even when strictly not on task (Sefton-Green, 2004). Morgan was able to develop his mapping skills and develop a sense of personal space within the game context in a manner that created a sense of achievement even though there may have been times when he may have been lost.

For Morgan the journey became both challenging and enjoyable when he was able to decipher the geographic information that surrounded the Pokemon world. Through exploration and refinement, Morgan used various maps to make sense of the unfamiliar pathways and destinations he encountered along his journeys. He quickly became familiar with a range of symbols and icons that were embedded in these maps and increasingly became aware of the maps within maps in this new world. Although young and relatively inexperienced in playing the game (having only played it on weekends for four months) he possessed an intimate knowledge of spatial arrangements that were essential in navigating through the game and developing a sense of purpose for the journey. Morgan’s “playing” became insightful and productive in a problem-solving context that remained challenging and productive. Moreover, his understanding of graphical languages, in an authentic context, had developed to a sophisticated level.
As his capacity to decipher graphical information became more sophisticated, he developed a growing confidence to explore more unfamiliar territories and foreign terrains. Flynn (2004, p. 58) maintained that “navigating is an act of speaking the language of the terrain, and through the improvised movements of the player spatial elements are transformed or abandoned”. As Morgan ventured into these foreign places he had to become more adventurous and more regularly relied on the interpretation of these maps. Significantly, his approached to the game change. He would access coordinate information from the magazines before deciding on routes to take. His problem-solving approaches went beyond trial-and-error strategies as he reconstructed scenarios and began to pose problems in open-ended ways. His knowledge of the Poke-world became detailed and he was able to remember pathways and recall specific incidents with a fine attention to detail. He was “forced” to simultaneously move between maps with different representations, orientations, perspectives and scale in order to make insightful decisions.

References


