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PRIMARY STUDENTS' PERFORMANCE ON MAP TASKS: THE ROLE OF CONTEXT

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This study investigated the longitudinal performance of 583 students on six map items that were represented in various graphic forms. Specifically, this study compared the performance of 7- 9-year-olds (across Grades 2 and 3) from metropolitan and non-metropolitan locations. The results of the study revealed significant performance differences in favour of metropolitan students on two of six map tasks. A second phase of the study analysed the difficulties non- metropolitan students (n=48) had when interpreting these two tasks. Implications include the need for teachers in non-metropolitan locations to ensure that their students do not overly fixate on landmarks represented on maps but rather consider the arrangement of all elements encompassed within the graphic.

INTRODUCTION

Being numerate in today's society requires increased demands on our capacity to represent, manipulate and decode information in various graphical forms (e.g., graphs, maps). New technologies allow data to be transformed into detailed and dynamic graphic displays (e.g, Google Earth) with increased complexity (and detail), and consequently, there is greater need for students to become proficient in decoding maps. At the same time, the tasks students are required to solve are becoming more authentic and realistic (van den Heuvel-Panhuizen, 2005)—and as a result the broad everyday experiences students possess are increasingly useful in decoding. . The purpose of this paper is to investigate the effect that students' lived experiences (in terms of geographic locality) have on their ability to decode maps. In particular, we examine the performance differences of students living in different everyday contexts (metropolitan and non- metropolitan areas). This research builds on a body of work which highlights the influence of contexts and contextual understanding in mathematics meaning making (de Corte, Verschaffel & Greer, 2000) and the transferability of real-world knowledge to school mathematics (Boaler, 1993).

UNDERSTANDING AND INTERPRETING MAPS

Information in maps is encoded through the spatial location of fixed marks and symbols (Mackinlay, 1999). Maps convey information graphically through elements such as coordinates, landmarks, simple icons, different perspectives, and common grids. Although maps are embedded in the school curricula from the first years of school, many primary students experience difficulty interpreting relatively simple maps (Logan, 2010). Diezmann and Lowrie (2008) found that students were distracted by different foci on the map; and that information critical to understanding was often overlooked. The ability to interpret or decode maps involves the student analysing: locations (through position and placement) and attributes (what is actually represented); and understanding that the map representation is presented within some form of scale and as a result are smaller depictions of real world place or spaces (Wiegand, 2006).

Map decoding occurs at three levels of sophistication (Muehrcke, 1978; Wiegand, 2006). The initial stage involves *extracting information from a map* and generally reading names and attributes. In this phase, the user records or recognises visual stimuli and is able to recognise and identify specific elements (or icons) that are contained within maps. The subsequent phase involves *ordering and sequencing information*. This could include monitoring, comparing, seriation and even manipulating information or data. These two levels of sophistication are contained in the tasks in the present study. The final level, *the application of information*, is not.

From an encoding perspective, previous research has found that students living in metropolitan locations generally encode maps (when drawing their own maps) in a grid-like structure whereas students in non-metropolitan areas often encode using landmark and "mud map" techniques (Lowrie, Francis, & Rogers, 2000). The present study investigates this supposition further by seeking to determine whether students from different geographical locations decode maps with different proficiency.

DESIGN AND METHODS

This study is part of a longitudinal investigation of primary students' ability to interpret information graphics. Two research questions are explored:

1. *Are there performance differences between students' from different geographic locations on Graphics items?*
2. *What difficulties do students from different localities experience on Map items?*

The Instrument and Items

The six map items from the Early Primary [EP-GLIM] Test and the Graphical Languages in Mathematics [GLIM] Test (see Diezmann & Lowrie, 2009 for a description of the Instrument) were used in the analysis. The multiple-choice instruments were developed to assess students' ability to interpret items from six graphical languages including number lines and maps. The six map items varied in complexity, required substantial levels of graphical interpretation and conformed to reliability and validity measures (Lowrie & Diezmann, 2005). The map items were administered to students in a mass-testing situation annually when students were in Grades 2 and 3. The Appendix presents the six items.

Participants

The participants (Cohort 1) comprised 583 students (M=271; F=313) from two distinct locations (Metropolitan=206 and Non-Metropolitan=377) across two states in Australia. The cohort completed the six map items from the EP-GLIM tests for each of two years (Grades 2 & 3, aged 7-9 years). Cohort 2 was 48 Grade 2 (aged 7 or 8 years) students from Non-Metropolitan location. Students' socio-economic status was varied and less than 5% of the students had English as a second language.

RESULTS

The first aim of the study was to investigate performance differences for mathematics tasks by location. A multivariate analysis of variance (MANOVA) was used to analyse mean scores across Grade and Location dependent variables. The MANOVA revealed statistically significant differences between the scores of students across both *Grade* [F(1, 6=7.13, p<.001] and *Location* [F(1, 6=3.09, p<.01] variables. There was no interaction (*Grade* x *Location)* effect [F(1, 6=0.38, p>.05]. Table 1 presents the means (and standard deviations) for grade and location over the two-year period.

Grade	Location	Q1	Q2*	Q3	Q4	Q5	Q6*
2	Met	.77	.76	.56	.58	.32	.53
	n=206	*.42*	*.43*	*.49*	*.49*	*.47*	*.50*
	N-Met	.80	.67	.52	.60	.32	.43
	n=377	*.40*	*.47*	*.50*	*.49*	*.47*	*.49*
3	Met	.87	.84	.50	.66	.41	.65
	n=206	*.39*	*.37*	*.47*	*.47*	*.49*	*.47*
	N-Met	.83	.77	.67	.67	.42	.48
	n=377	*.37*	*.42*	*.47*	*.47*	*.49*	*.50*

* Statistically significant at p<.007

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

A Bonferroni correction method was calculated in order to determine where differences were with respect to tasks across location (probability value p = .05÷7 = .007). Subsequent ANOVA's revealed statistically significant differences in the performance of students on two tasks across the two locations of the study: namely, Task 2, *The Bike Task* [F(1, 873=7.66, p<.007], a coordinate map, and Task 6, *The Playground Task* [F(1, 873=9.45, p<.007], a landmark map.

The second aim of the study was to determine the difficulties that non-metropolitan students experienced when solving these two map items. Table 2 and 3 outline the type of solution approach employed by students on *The Bike Task* and *The Playground Task* respectively. For *The Bike Task*, the most common correct solution approach (42%) involved students using a visual cue (the key) and eliminating the other answer options in a systematic manner. Other correct solution responses were spread evenly across three other appropriate solution approaches (see Table 2).

Response type	Solution approach	No. of responses
Correct	Used visual cue and eliminated	8
	Worked from the Key	4
	Process of elimination	3
	Used and understood coordinates	4
Total correct		*19*
Incorrect	Misinterpreted diagram	8
	Incorrect counting	3
	Guessed/unable to verbalise	16
Total incorrect		*27*

Table 2: Solution Approaches (n=46) for *The Bike Task.*

The majority of incorrect solutions (59%) were associated with students' lack of understanding about what the task entailed. These students were unable to verbalise their approach or there was evidence they had guessed their solution. For example, Joseph's response gave no real insight into his thinking and how he approached the task.

> Well I couldn't actually figure it [out] I just took a guess...Yeah it says A5, B5, A4, and B4 and there's no B4, A4 or anything [*on the map*].

It could be that these students were not ready to verbalise their thinking, and hence, were only able to give a vague indication of how they solved the task. Other incorrect students misinterpreted the diagram (30%), focussing on landmarks that were not relevant to the task. As Lily's explanation highlights, these students had some understanding of the map elements however they were not able to apply this knowledge to the task (i.e., managing the relationship between the coordinate points and the overlay of the bike track representation).

> Well, she can't go through there, she can't go through the playhouse, she can't go through there, she can't go through the toilets, she can't through the picnic tables, she can't go through the water bubblers... [*eliminating items - pointing to items on the map*]. She

could go through the swings ...but, I didn't really want to pick that. So I picked the sandpit - that's what she could've gone through.

Consequently, these students were unfamiliar with the representation of a map in a coordinate structure—potentially because they had not encountered such graphics in-school or out-of-school contexts.

For *The Playground Task*, 96% of students who correctly solved the task monitored the number of times they crossed the track as they located the landmarks. By contrast, the majority of students (72%) who answered incorrectly located the landmarks, however, were not able to monitor the number of times they crossed the track as they followed the route. Instead, they counted the number of landmarks presented in the text stimulus. These students misunderstood the final part of the question asking how many times the track was crossed. For example, Jackson did not interpret the question properly and got confused by what he was meant to do.

Jackson: My answer was four. I wrote down all the things he went past and it came up as 4 (counted the number of landmarks)

Jackson's response is indicative of students who misread the intent of the task and concentrated on the landmarks as opposed the sequential movement between them.

Response type	Solution approach	No. of responses
Correct	Described how the track was crossed	22
	Counted landmarks	1
Total correct		*23*
Incorrect	Misinterpreted diagram	3
	Incorrect counting	1
	Vague	2
	Counted landmarks	18
	Read map incorrectly	1
Total incorrect		*25*

Table 3: Solution Approaches (n=48) for The Playground Task.

DISCUSSION AND CONCLUSIONS

Our study examined the effect contextual experiences and location had on the performance of primary-aged students' capacity to decode items rich in graphics. The only items where metropolitan and non-metropolitan students differed were on a coordinate-map and a landmark-map task. The source of the difference between the performances of students on the coordinate task (The Bike Task), in favour of the metropolitan students, could be experience related. It is possibly the case that metropolitan students are more likely to be exposed to coordinate map systems than those students in non-metropolitan areas—especially in out-of-school contexts as they interpret train timetables, navigate bus routes and have a lived experience in the grid-like structure of a city.

More surprisingly is the fact that the non-metropolitan students' results were comparatively low on the landmark-based task (The Playground Task) given previous research on encoding/drawing maps (Lowrie, Francis, & Rogers, 2000). Most of the non-metropolitan students were unable to move beyond the first level of map decoding of locating landmarks and following directions. This level of processing was required for the four tasks where no performance differences occurred (Tasks 1, 3, 4, & 5). Conversely, the two tasks where differences were noted required a second level of processing which required the students to monitor movement beyond the location of landmarks (Wiegand, 2006). Students needed to decode information and interpret the map beyond direct instructions. For example identifying were Deb would *not* ride her bike and considering how many times a track was crossed on a route rather than locating the end destination. It appears the additional requirement for students to locate information besides what was provided in the direct instructions proved challenging for non-metropolitan students.

IMPLICATIONS

A number of implications emerged from the study. First, it is important that students of this age group are exposed to tasks which require the processing of information at Wiegand's (2006) second level of decoding. This research shows that non-metropolitan students have not acquired such experiences and we propose that it is less likely that these students gain an awareness of such understandings in out-of-school contexts. Second, students need to better understand the relationship between map structure and the elements embedded within a map. In this way, students who are unfamiliar with particular map representations (e.g., coordinate graphs) can still utilise general map principles to decode the graphic elements. The findings of this study indicate that further research needs to be conducted in this area—and especially on map tasks that require the interpretation of multiple representations, higher levels of decoding and embedded map structures. Moreover, further research needs to be conducted as to why metropolitan students have developed such experiences.

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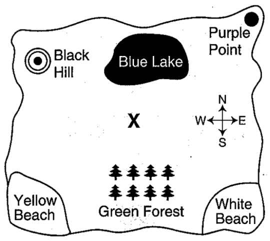
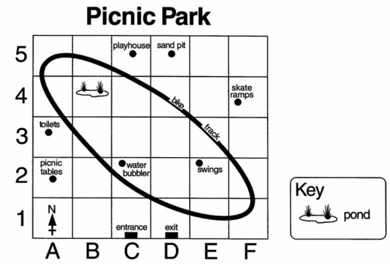
APPENDIX

<table>
<tr>
<td>

This is a map of Colour Island.
Pete the Pirate is standing at X. From there, he walks south and then west.
Where could Pete the Pirate be now?</td>
<td>

Deb rides her bike along the bike track.
What part of the Park won't she ride through?</td>
<td>Danni is playing a game.
Danni begins on the Start box and moves as far to the left as


she can. She then moves to the diagonally opposite corner.
Which shape will she finish on?</td>
</tr>
<tr>
<td>Task 1. EAA (2006)</td>
<td>Task 2. QSA (2001)</td>
<td>Task 3. ETC NSW (2001)</td>
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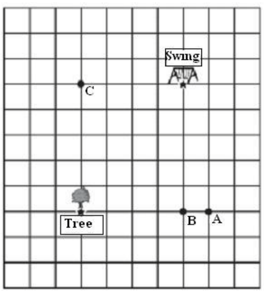
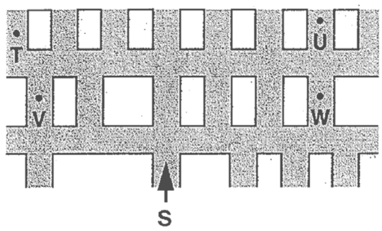
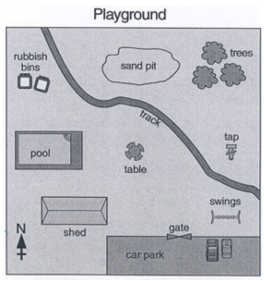
<tr>
<td>

Some children want to hide some treasure 5 units from the tree and 4 units from the swing.
At which labelled location can the children hide the treasure?</td>
<td>

Omar is at S moving in the direction of the arrow.
If he follows these directions: take the second turn to the right, then take the third turn to the left, he will be at point?</td>
<td>

Ben went from the gate to the tap, then to the shed, then to the rubbish bins.
How many times did he cross the track?</td>
</tr>
<tr>
<td>Task 4. MDE (2006)</td>
<td>Task 5. ACER (n.d.)</td>
<td>Task 6. QSA (2002)</td>
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