LEARNING ENVIRONMENTS IN MATHEMATICS: EXPLORING PUPIL PERCEPTIONS

ANDREA MCDONOUGH
Mathematics Teaching and Learning Centre
Australian Catholic University (Victoria) - Christ Campus

INTRODUCTION

The development of an effective learning environment has for some time been the concern of the mathematics education community as demonstrated over the past two decades by teachers introducing strategies such as grouping for instruction and cooperative learning methods into their classrooms. In major Australian and international documents emphasis is given to the creation of a suitable learning environment in the classroom (e.g. The Mathematics Framework P-10, 1989; MCTP Curriculum Package, 1988; *The National Mathematics Statement*, 1990; and Professional Standards for Teaching Mathematics, 1991). Physical, social, organisational and academic factors are perceived to contribute to the creation of a learning environment where classrooms are seen as mathematical communities fostering the development of students' mathematical power. The 1991 teaching standards document (NCTM) makes reference to physical space, materials, goal-setting, exploration of problems, and listening to, responding to and questioning one another as some of the factors which may be present in a classroom which supports the teaching and learning of mathematics.

Studies related to the primary classroom environment include those of Fraser (see for example, 1984; 1986). His 1984 publication details five instruments for gathering student perceptions of the classroom environment, one of which, the My Class Inventory (MCI), has been developed for use with primary level pupils of eight to twelve years. This yes-no format questionnaire gathers data on pupil perceptions of the following aspects of the class environment: Cohesiveness, Friction, Difficulty, Competitiveness and Satisfaction. Actual and preferred versions have been developed. While, according to Fraser, the actual classroom environment version has been used more frequently, both versions have been utilised in studies, for example in Fraser's (1986) investigation of discrepancies between grade three children's preferred and actual classroom environments.

Muscella (1986) developed a perception of classroom environment instrument which was suitable for use with younger children. To explore interpretations of the class environment, the researcher asked kindergarten pupils to select favorite learning situations from representations given in adult-drawn sketches of the actual class situations. Muscella's instrument facilitated expression of ideas by children younger than those who are able to respond to written questionnaires such as the My Class Inventory.

It is apparent that data collection from younger children in the primary school, in particular, continues to pose challenges for the researcher, and that very little learning environment research has gathered data on the perceptions of primary school children. Few studies have actually asked children to indicate what they believe is for them an effective learning environment, particularly for the curriculum area of mathematics. In studies such as those of Fraser, analysis has focussed on factors such as competitiveness, difficulty, and satisfaction. However, as demonstrated in the literature (for example

Victorian Ministry of Education, 1988; NCTM, 1991), other more concrete factors such as grouping structures, manipulatives, and tools for discourse also contribute to the mathematics classroom environment.

In the current study a drawing and description instrument has been developed for use in the primary school which, most importantly, can expand the research data base for claims regarding effective learning environments, particularly for the learning of mathematics. It is considered that the instrument can have the potential to be used on a small scale by the primary level class teacher as a diagnostic tool providing insights into the preferences and needs of the individuals in his/her class, with its larger scale use in the present study providing data for comparison by the individual teacher or other researchers. The instrument provides insights into pupil preferences for learning environment factors different from those which have been the focus of many previous studies.

METHODOLOGY

Subjects

Data were gathered from five multi-age schools and four conventional, straight grade schools, resulting in the administration of the instrument to 26 multi-age classes and 25 conventional, straight grades. The gender groups were represented in similar numbers with 645 girls and 600 boys in the population of the study.

Sampling and Administration

Schools were selected through opportune sampling with the objective of a study population of approximately 1200 students, with similar numbers of students from each year level 1 to 6, with similar numbers of students from multi-age classes and from conventional straight grades, and with a gender balance.

Participant class teachers administered the instrument to their students. The instruction "Think of a situation in which you are learning maths well. Draw it. Show the people, the things around you and what you are doing." was written on the blackboard and read through with the class. Children proceeded to draw a picture of their preferred situation. Upon completion of the picture a six item questionnaire was distributed. Children used this to describe their drawings. Some of the younger children's questionnaire responses were transcribed by the teacher, with the children describing their completed drawings in their own words. Teachers provided information on the depicted tasks by completing a Teacher Perception Sheet for each child.

Once data were collected they were divided into sub-groups according to school type (multi-age and straight), class level (1, 2 , 3, 4, 5 and 6) and then gender. Following this, a one-third random sample of each sub-group was selected. A table of random numbers was used. The year 1 level multi-age data was treated differently; as only 28 responses were gathered, sampling did not occur. However, as the multi-age level 1 responses came from three classes, this was considered justifiable.

Analysis

Drawing, Description and Teacher Perception data were combined and considered one data source for each child. They were examined in terms of:

The sample population: n=427;
Class type: multi-age=213, like-age=214; and
Gender groups: males=206, females=221;
Year level: 1 to 6.

An analytic structure had been developed in stage one and two of the study. The analytic categories were: Location; Instruction Type; Adult Role; Adult Presence; Tools; Task Type; and Most Helpful Factors. They each consisted of elements considered in the analysis which employed frequencies, means and chi square contingency tables.

FINDINGS

Location

While it had not been specified that the learning environment be a school one, the most frequently depicted location among the sample population of 427 primary school pupils, for a personally effective mathematics learning environment, was the Classroom (70%). The Home was the second most frequently depicted location (15%).

Within the whole sample Class Type was a source of significant variance in student preferred location (n=427, Chi square=22.33 DF=5; p=.0005). Table 1 shows the location element results which most markedly differed from the expected values. The expected values are shown in brackets. It appears that the greatest source of variance was Home data. This location was seen as an effective learning environment in mathematics by 22.43% of the straight grade children and by 7.98% of the multi-age class children. Another major contribution to the variance came from Classroom location, chosen by 62.15% of the straight grade children and by 78.87% of the multi-age class children.

Further analysis of the results from the whole sample showed that grade level, but not gender, was a source of significant variance (n=427, Chi Square=48.73, DF=25, p=.0039). The trends observed were that frequency of Classroom depiction was higher for grades 4, 5 and 6 than for the sample as a whole with the greatest differences being for years 5 and 6, and the frequency of Classroom depiction was lower than expected for grades 1, 2 and 3, with the greatest difference being in grade 2. This suggests a basic trend for children to increasingly associate learning with school environments as they progress from infant to upper primary classes.

Table 1: Student Preferred Locations, Multi-age and Straight Grades - Observed and Expected Frequencies

Location	Class Type Multi-Age	Straight
Classroom	168 (150.15)	133 (150.85)
Playground	4 (6.48)	9 (6.52)
Home	17 (32.42)	48 (32.58)

The Multi-age sample Location results did not show any significant variance within grade level or gender group results. Within the Straight grade sample there were no significant differences in Location preference among the gender groups. However, within the Straight grade sample, grade level was a source of variance in choice of Location for the effective learning of mathematics (n=214, Chi Square=49.98, DF=25, p=.0021). This suggests that the significant differences observed in the overall sample data largely stemmed from the straight grade data. The results from the straight grade sample are given in Table 2. It should be noted that the Expected Frequencies are presented in parentheses in Tables 2 to 5, as was the case in Table 1.

Table 2: Student Preferred Locations, Straight Grades - Observed and Expected Frequencies

	Grade					
Location	1	2	3	4	5	6
Classroom	20 (25)	16 (21.9)	16 (20.6)	25 (22.5)	28 (20)	28 (23.1)
Playground	1 (1.7)	0 (1.5)	4 (1.4)	1 (1.5)	0 (1.4)	3 (1.6)
Home	15 (9)	14 (7.9)	10 (7.4)	5 (8.1)	3 (7.2)	1 (8.3)

While a Home situation was represented by only 15% of the whole sample it is clear from the above results that more of the younger children considered this environment instrumental in their effective learning of mathematics than did the older children. This result suggests that a number of the younger children were able to identify a mathematics learning situation which did not carry the label of a 'mathematics lesson' as such. This adds weight to the belief that the instrument is suitable for the younger children and that they are able to give a considered response to an instruction which asks them to identify a situation in which they feel they are learning maths well.

Instruction Type

Over the whole sample the most frequently depicted Instruction Type was Individual Non-Instruction (33.25%), meaning that the child was working by himself or herself with no direct assistance from a teacher or other adult. Group Non-Instruction was the second most frequently depicted Instruction Type (26.23%). Group Non-Instruction situations did not include direct contact with a teacher or other adult. Class Instruction and Class Non-Instruction were the least frequently depicted elements.

By combining the elements into the three sets of Class, Individual and Group, the preferences for grouping structure alone can be examined. This reveals that Individual was preferred by 51.99% of the respondents, Group was preferred by 38.88%, and Class preferred by 9.13%.

Class Type (multi-age or straight) was a significant source of variance in preferred Instruction Type for the effective learning of mathematics (n=427, Chi Square=39.91, DF=5, p=.0001). As seen in Table 3, Individual Non-Instruction was the element of least variance. This element was depicted by 31.92% of the multi-age sample and by 34.58% of the straight grade sample.

The multi-age classes showed a higher frequency of preference for Group Non-Instruction, Group Instruction and Class Non-Instruction than was the case for straight grade classes. Class Instruction and Individual Instruction were depicted more frequently by those in the straight grades than by those in the multi-age classes. The whole sample class type Instruction Type results are detailed in Table 3.

Further analysis of the Instruction Type data in terms of gender groups and grade levels, across the whole sample and according to each of the class types, revealed no other sources of significant variance. Of the variables addressed in this study, Class Type was the only source of significant difference in preferences for effective mathematics learning environment Instruction Types.

Table 3: Instruction Type, Multi-age and Straight - Observed and Expected Frequencies

	Multi-age	Straight	Totals
Class Instruction	6 (12.47)	19 (12.53)	25
Class Non-Instruction	9 (6.98)	5 (7.02)	14
Individual Instruction	22 (39.91)	58 (40.09)	80
Individual Non-Instruction	68 (70.83)	74 (71.17)	142
Group Instruction	33 (26.94)	21 (27.06)	54
Group Non-Instruction	75 (55.87)	37 (56.13)	112
Totals	213	214	427

Adult Presence

46.84% of the sample group chose an effective learning situation in mathematics which was characterised by the absence of a teacher or other adult. The majority of drawings did include an adult in one role or another (see Adult Role, below). Analysis for the whole sample showed that neither Class Type nor Gender nor Grade Level were sources of significant variance.

Within the multi-age sample Grade Level was a source of variance in depiction of Adult Presence (n=213, Chi Square=17.299, DF=5, p=.004). In grades 3 and 5 preference for adult presence was higher than for the sample as a whole, while in grades 1 and 2 it was lower. The full results are shown in Table 4.

Table 4: Adult presence, Multi-age - Observed and Expected Frequencies

Grade	1	2	3	4	5	6
Adult Present	7 (13.93)	11 (15.43)	27 (18.91)	21 (21.4)	23 (19.91)	17 (16.42)

Adult Role

Of the 7 elements within the Adult Role category, six of which involved some sort of adult presence and one of which did not, the No Adult element was the most frequently depicted (46.84%). Adult and Child situations were the second most frequently (21.55%).

Analysis of the sample data revealed that Class Type was a source of significant variance in the preferences for Adult Role in the preferred mathematics learning environment situations (n=427, Chi Square=17.891, DF=6, p=.0065). As shown in Table 5 which details the element data to which the variance is likely to be attributed, the children from multi-age classes showed stronger preferences for Adult and Child (Group) and for No Adult while the data from straight grade respondents revealed higher than expected preference for Adult and Child, and Adult and Class.

Table 5: Adult Role, Multi-age and Straight - Observed and Expected Frequencies

	Multi-age	Straight	Totals
Adult and Child	32 (45.89)	60 (45.11)	92
Adult and Child (Group)	41 (31.43)	22 (31.57)	63
Adult and Class	10 (13.97)	18 (14.03)	28
No Adult	107 (99.77)	93 (100.23)	200

Grade level and gender group data did not reveal any statistically significant differences in adult role depicted in the preferred learning environments. Sources of variance were only found in the Class Type data.

Tools

Only frequencies were calculated as the data category elements were not mutually exclusive. Figure 1 shows the results from the overall sample for the elements: Computer, Calculator, Other Materials, Text, pencil and Paper/Worksheet etc., Nothing, Unclear.

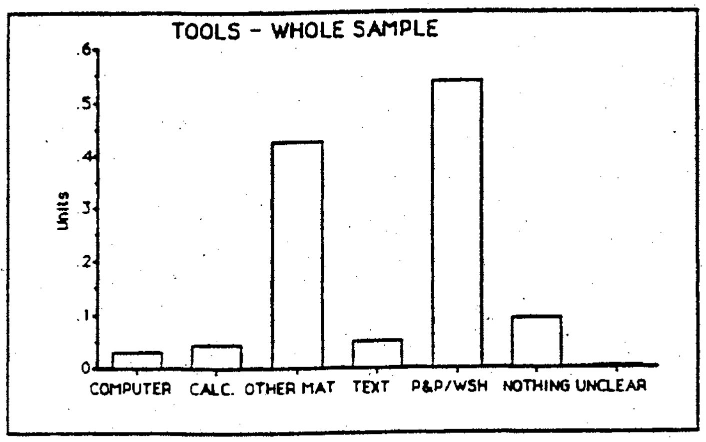

Figure 1: Tools, Whole Sample, Frequency of Depiction

It is clear that items of the Pencil and Paper/Worksheet category were the most frequently depicted (229). Materials were depicted 212 times in total (combination of Computer-12, Calculator-18, and Other Materials-182).

Closer examination of the class type, gender group and grade level results indicated some interesting differences. These are presented in Tables 6 and 7:

Table 6: Selected Tools, Multi-Age and Straight Grades

	Multi-Age	Straight
Calculator	4	14
Text	19	2

Table 7: Selected Tools, Male and Female

	Male	Female
Computer	8	4
Other Materials	77	105
Text	7	14

The Grade Level results indicated preferences which might have been expected. These included more preference for Other Materials in the lower grades than in the upper grades and less preference for Pencil and Paper/Worksheet in the lower grades than in the upper grades. There were more drawings by children in the upper grades in which no tools were depicted than in the lower grades.

Tasks

To gather information on depicted tasks teachers provided their perception of the child's task in terms of five criteria. The results presented in Table 7 indicate that for the whole sample, the tasks were predominately judged to be largely of a closed, other-directed nature. Possible values were 1 to 4, with a lower value indicating an open, self-directed, creative task.

Table 8: Tasks, Whole Sample, Mean values

Task Type	Mean	Standard Deviation
Inventing/Practising [Method]	3.314	.932
Discovering/Recalling [Information]	3.014	1.09
Exploring/Using [Tools]	2.972	1.072
Self-directed/Other-directed	3.007	1.118
Open/Closed	3.227	1.043

Analysis indicated that Class Type was a source of variance for Discovering/Recalling (n=422, Chi Square=9.424, DF=3, p=.0242). The multi-age sample scored higher than students in conventional classes, indicating more preference for recall tasks.

Gender was not a source of variance for any of the task descriptors. In contrast, grade level was a source of variance for all five items:

i) Inventing/Practising (n=421, Chi Square=38.979, DF= 15, p=.0006) The most notable results were at the grade 1, 2, and 4 levels which showed higher levels of Inventing than was true for the sample as a whole. This trend was particularly evident at the grade 2 level.

ii) Discovering/Recalling (n=422, Chi Square=42.262, DF=15, p=.0002) The most obvious variation was in the grade 2 group which was perceived to be Discovering twice as often as students in the sample as a whole. The general trend was preference for more Recall tasks in the upper school than in the lower school..

iii) Exploring/Using (n=394, Chi Square=29.135, DF=15, p=.0155) Grade two showed the most variation from the total sample, being nearly twice as likely to have depicted Exploring tasks (that is, having scored 1).

iv) Self-directed/Other-directed (n=421, Chi Square=28.213, DF=15, p=.0203) Grades 1 and 3 scored more ones (self-directed) than other grade levels. However, when the frequency of occurrences for both the 1 and 2 self-directed scores were combined, it was found that grades 1 and 2 scored higher on the self-directed end of the scale.

v) Open/Closed (n=422, Chi Square=43.944, DF=15, p=.0001). The grade 2 sample was most distinctive, clearly scoring a greater proportion of ones than other groups.

It is not entirely surprising that the trends all point in the one direction as the items are obviously related and as the scores given on each of the five items related to the one situation depicted by the child. However, it is interesting to note that it is at the grade 2 level that the children in this study showed more preference than at other levels for self-directed, open tasks.

Most Helpful Factors

The final data source was the responses to questionnaire item six, an item of an open nature which asked the respondents to identify the aspect(s) in the picture that was **most** helping them to learn maths well. This item encouraged focus upon, and identification of, the particular factor or factors which were perceived by the child to be instrumental in his/her effective learning of mathematics. Factors classified by the researcher under the Tools category (for example, manipulatives, pencil and paper) were the most frequently mentioned, Interaction category items (for example, teacher encouragement, peer assistance) were the second most frequent and Activity category items (for example, measuring, written procedures, mental computations) were the third most frequent . For each category there were similar results from the two class type sample groups. However, a break-down of the Class Type Interaction data produced some interesting results shown in Table 8.

Table 9: Selected data, Most Helpful Factor(s), Multi-age and Straight grades

	Multi-age	Straight
Adult Interaction	41	56
Peer Interaction	17	0

Closer analysis showed that the multi-age sample's preference for peer interaction came only from grade 4, 5 and 6 multi-age students.

SUMMARY

In summary, the following points can be made.

- Preference was shown for a Classroom location by the sample as a whole. However, a group of children in the lower grades, particularly from the straight grade sample, identified Home as an effective learning environment for mathematics. This suggests a trend of increasing association of learning with school as students move from Infant to Upper Primary grades.

- The most frequently depicted Instruction Type situations were Individual Non-Instruction and Group Non-Instruction, each of which involved no direct contact with an adult. The multi-age sample showed significantly high levels of preference for Group Non-Instruction, Group Instruction and Class Non-Instruction and, as a consequence the straight grade sample showed correspondingly higher preferences for Individual Instruction and Class Instruction.

- In the whole sample more children portrayed an adult in their picture than did not. However, the differences were minimal. In the multi-age sample, grade level was a source of variance, with more grade 3 and 5 children and less grade 1 and 2 children portraying an adult.

- Twenty-one percent of children showed an adult having direct interaction with themselves, and fifteen percent showed an adult having direct contact with their group. Class Type was a source of variance with the straight grade sample showing a higher preference for "Adult and Child" and "Adult and Class", and with the multi-age sample showing a greater preference for "Adult and Child (Group)", and "No Adult".

- Combined materials were represented 212 times, Pencil and Paper/Worksheet 229 times and text 21 times. The multi-age sample showed a small, but clearly greater preference for a text than did the straight grade sample. Females showed more preference for materials than did males.

- Grade 2 children were perceived to prefer more tasks of an open or exploratory nature as compared to the other grade levels.

Whether the differences which have become apparent in the preferences of children in multi-age and straight grade classes are a result of their present learning experience is not known. The fact that some children are known to have chosen situations which they experienced in previous years indicates that this is not necessarily the case. However, it has become apparent that information on when the experience occurred and on the stability of a child's perception of an effective learning situation in mathematics would be of value. These are possible avenues for further research.

The research reported in this paper was funded in part by a grant from the Campus Research Committee, Christ Campus, Australian Catholic University.

REFERENCES

Curriculum Corporation (1991). *A National Statement on Mathematics for Australian Schools.* Carlton: Curriculum Corporation.

Lovitt, C., & Clarke D.M. (1988). *MCTP Professional Development Package, Activity Bank - Volume 1.* Canberra: Curriculum Corporation.

Fraser, B.J. (1984). Differences between preferred and actual classroom environment as perceived by primary students and teachers. *The British Journal of Educational Psychology 54* 336-339.

Fraser, B.J. (1986). *Classroom environment.* London: Croom Helm.

Muscella, D. (1986). *Perceptions and preferences of a learning environment: Multi-dimensional scaling approaches.* Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco.

National Council of Teachers of Mathematics (NCTM) (1991). *Professional standards for teaching mathematics.* Reston, Virginia: NCTM.

Victorian Ministry of Education (1988). *The mathematics framework P-10.* Melbourne: Ministry of Education (Schools Division).