

Count Me Into Space

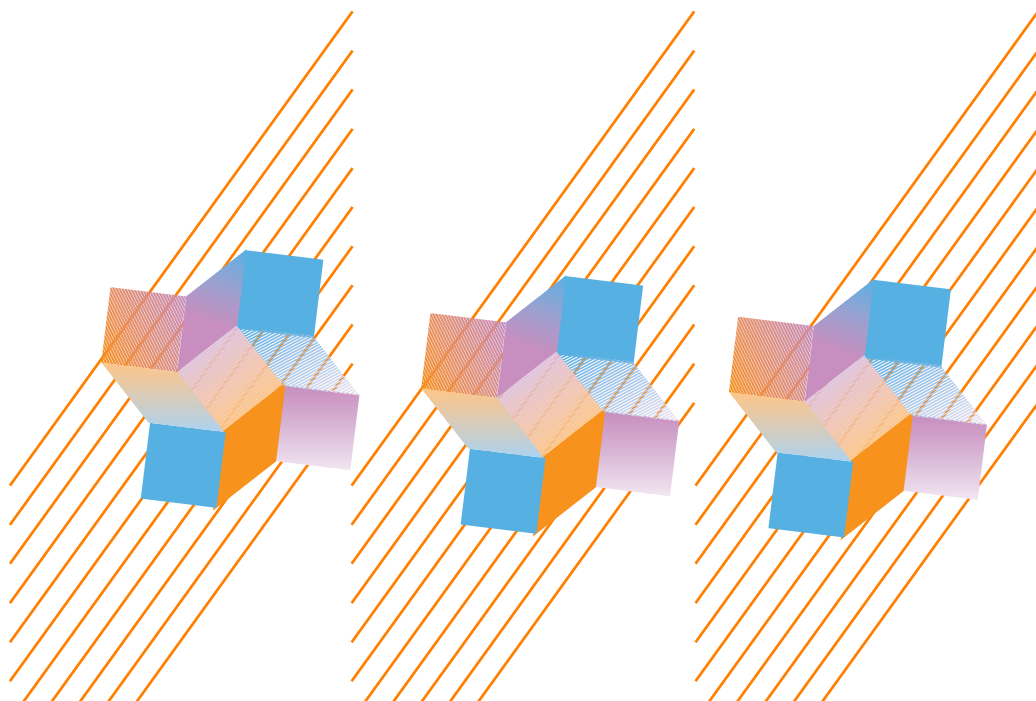
Implementation over two years with
consultancy support

2002 Report

A report prepared for the New South Wales
Department of Education and Training

by

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Professional Support and Curriculum Directorate

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CONTENTS

| | |
|--|-----------|
| EXECUTIVE SUMMARY | 5 |
| Procedure | 5 |
| Results | 5 |
| Teachers' comments | 6 |
| Recommendations from the second implementation with consultants | 7 |
| | |
| FOLLOW-UP STUDY OF THE SCHOOLS USING COUNT ME INTO SPACE AND MATCHED NON-INTERVENTION SCHOOLS | 8 |
| Background | 8 |
| Research questions | 8 |
| Procedures | 8 |
| Assessing students' learning | 8 |
| Evaluating teaching and the program | 9 |
| Data analysis | 9 |
| Student results | 10 |
| Change over time | 12 |
| Comparison of scores on three-dimensional test for intervention and non-intervention students | 14 |
| Changes in efficacy | 15 |
| Responses from teachers to open-ended questionnaires | 17 |
| Comments on lessons | 19 |
| Part-whole relationships | 20 |
| Orientation and motion | 23 |
| Teachers' final meeting | 26 |
| | |
| CONCLUSION | 27 |

EXECUTIVE SUMMARY

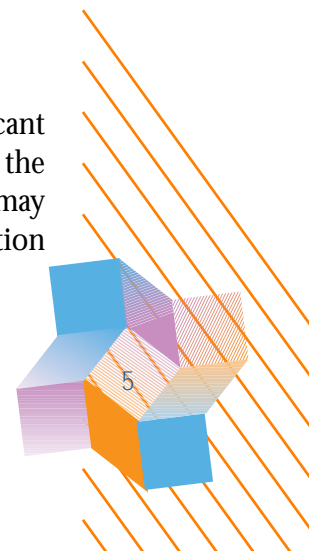
This report extends the results that were provided by the report on the 2000 implementation of the *Count Me Into Space (CMIS)* program (Owens, 2001). In particular, it indicates how the students' responses to the assessment tasks in intervention schools compared to the responses of students in control schools after a six-month period without any intervention in either group. Following a second year of implementation, information on the students and teachers' comments on the questionnaires was gathered and reported. It should be noted that not all of the same teachers participated in the program as new teachers entered the school or program. However, the consultants provided inservice for these new teachers and used the videotapes. Teachers were also able to use the improved lesson plans and assessment tasks. It was particularly important that the teachers in Year 1 had additional lessons on part-whole relationships as the students had experienced many of the original set of lessons during Kindergarten. The report should also be read in conjunction with the report on the implementation of *Count Me Into Space* with school-based facilitators (Owens, 2002).

PROCEDURE

The five intervention schools and five matched non-intervention schools involved in 2000 participated again in 2001. A total of 14 teachers were involved in the intervention schools. Before the program, the researchers used the task-based interviews with eight students in Year 2 and Year 3 (this was a sample only of students assessed previously in the intervention schools) and gave the Year 3 students a test *Thinking About 3D Space*. The teachers assessed students in Year 1 whereas the researchers interviewed students in the non-intervention schools in Year 1. The teachers also assessed kindergarten students. Results after the program in the intervention schools were provided by the teachers. The Kindergarten and Year 1 students were involved in lessons on part-whole relationships while the Year 2 students had lessons on orientation and motion. The observing and reporting of students' responses to the tasks by the teacher was part of the implementation of the program. Teachers presented and reported on ten lessons. Teachers also completed questionnaires with both Likert-scale items and open-ended items. The consultants supported new teachers and met with the teachers at the end of the program. The CMIS videotapes were available as part of the revised kit for teachers.

RESULTS

While results in the previous year showed statistically very significant differences between the intervention and non-intervention schools, the same significant difference was not found after a six-month delay. This may have been the result of the enthusiasm of teachers in non-intervention



schools, the reduced sample size, or the researchers assessing the students. Nevertheless, teachers found statistically significant improvements on the post-intervention assessments.

The time-series results indicated that intervention had considerable impact on responses to the tasks. This was apparent for two interventions and also for a control school who had intervention after a previous period of non-intervention.

There was no significant difference between the intervention and non-intervention students on the test *Thinking About 3D Shapes*. However, the lowest third of the students did show significant differences in the confidence intervals for the means of the groups. The test has items similar to those used for intelligence tests, especially of spatial abilities so this may be influencing results.

There was a lack of data collected from the pre-intervention questionnaires on efficacy and reduced questions on it in later questionnaires so that results on how and why students feel about doing space mathematics are limited.

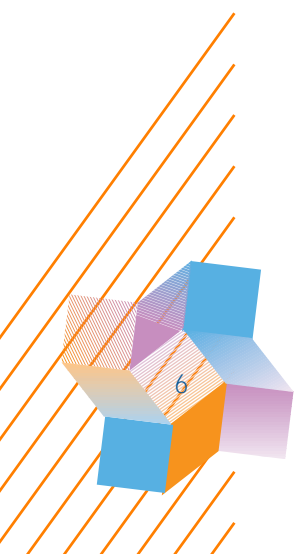
TEACHERS' COMMENTS

Teachers made comments on the kits and framework that indicated they provided considerable assistance to teachers in efficiently implementing the lessons and providing background knowledge but they still needed a consultant (as facilitator) to clarify the purpose of lessons and other issues. Overall teachers commented on usefulness and students' enjoyment of the lessons. Some teachers felt the lessons were not suitable for their students or found the language of the framework or of the assessment tasks difficult.

Teachers commented at length about the changes in their teaching. Lessons were in some ways less structured with more incidental learning and small group learning, and more changes in the direction of the lesson with students dictating how the lesson goes. At the same time, "questions were now more towards what they are doing and why". One teacher commented on being "much more committed to the value of concrete materials and also opportunities for the students to practise and explain". Teachers commented on "better understanding of space, and moved away from space lessons just being recognition of shapes" and "more open to various ways to teach certain concepts." Some responses noted the connection between more structure and more depth of teaching.

Teachers were also better able to explain how their students were learning and what they knew about part-whole relationships.

There were a few comments that suggested some teachers were still reluctant users and lacked comfort with the materials and the lessons and tasks. However, teachers liked the sequence of lessons and were able to give comments on the lessons that suggested a greater degree of familiarity with the purpose of the program after the two years.



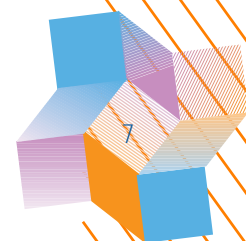
Teachers commented on students' enjoyment and participation. The teachers could give general and specific examples of learning. They were particularly pleased with the students' use of language and they now had higher expectations of their students.

RECOMMENDATIONS FROM THE SECOND IMPLEMENTATION WITH CONSULTANTS

1. Write the assessment tasks as lessons with an observation checklist so teachers can implement for a whole class. Inform teachers that the assessment of five students was partly as training for themselves to understand the framework.
2. Make it clear how the lessons and tasks interrelate in terms of the framework. Perhaps a lesson similar to the task could be written and the other lessons clearly linked to the idea.
3. Continue to provide time for teachers to familiarise themselves with the materials. The lessons could be chunked under purpose rather than just ordered. Teachers need to meet regularly to talk in terms of the framework.
4. Some teachers need to feel more ownership of the program. This may be achieved by greater facilitation support from fellow teachers, a greater discussion of the purpose of the lessons, recognition of their comments such as the need to make lessons more appropriate for their students at their level of development, and encouragement for teachers by providing release time to prepare their own lessons of a similar kind or discuss modifications of the current lessons to improve their suitability. The two-pages for each lesson in a loose-leaf folder caused some difficulty and a ring-backed book was suggested as an alternative. Teachers found it difficult to decide on strategies being used in the assessment tasks and the format and recording on tasks needs revising. Recommendations on these are given in the report on the implementation of CMIS with school-based facilitators.
5. Some of the good suggestions on lesson plans could be given on the lesson plan page as a teacher's talking bubble. For example on the squares and more squares on the geoboard lesson:

It helped to have students working in pairs to discuss and self correct their attempts at making squares etc.

I gave the students different sized bands and made sure the dot paper was cut so it had the same number of row and columns as the pegs.



FOLLOW-UP STUDY OF THE SCHOOLS USING *COUNT ME INTO SPACE* AND MATCHED NON-INTERVENTION SCHOOLS

BACKGROUND

In 2000, five schools from three districts implemented the *Count Me Into Space* program and five schools from the same districts were also selected as non-intervention schools. The report indicated that the students in the intervention schools improved considerably more than those students in the non-intervention schools on the student assessment tasks. A full report of the teachers' comments and classroom observations is available (Owens, 2001).

During 2001, five of the intervention schools continued with the program. We particularly wished to see if the good results for the intervention schools were maintained after six months without intervention.

Research questions

The following became the key questions.

- Are students developing investigating and visualising strategies and progressing through the strategies in comparison to control schools?
- Have students in Year 3 developed 3D spatial thinking skills in comparison to other schools (previously given the test)?
- Are students improving in describing and classifying, especially in new situations?
- Are teachers developing their knowledge of the framework?
- Are the learning experience plans satisfactory?

PROCEDURES

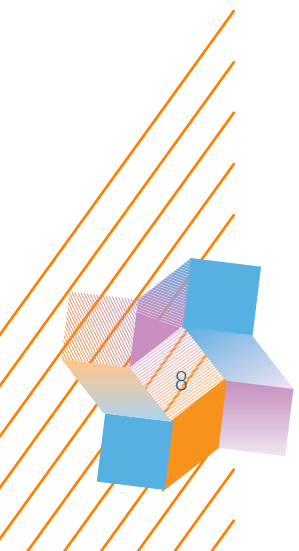
Assessing students' learning

Year 1 students (who were in Kindergarten in 2000) participated in new part-whole relationship activities and some of the structured play activities on orientation and motion. At the end of the time, eight students from each class were assessed on part-whole relationships again.

Year 2 students participated in orientation and motion structured play and main lessons. The eight students were given both the part-whole relationship tasks (by the researchers) before the program recommenced in 2001 and the orientation and motion tasks by the teachers at the beginning and end of the term.

Year 3 students (at least eight from each school) in both the intervention and non-intervention schools were also given the test *Thinking about 3D Shapes* and the orientation and motion tasks again. (The class also began lessons on angles work.)

Implementation over two years with consultancy support



All students were asked questions on their confidence, frame-of-reference for assessing their achievements, and knowledge of space mathematics. The questions were a selection from the longer attitude survey given the previous year.

Evaluating teaching and the program

Any teacher who was new to the program in Years 1 and 2 was inserviced by the consultant. All teachers could view the new CMIS professional development videotapes.

At the end of the ten weeks, teachers in the school met for discussions, handed in the list of lessons that they taught and any comments they may have made on the lessons. They provided reports on the new lessons, commented on what they understood better and whether they were more comfortable with the observing and recording tasks and lessons. They were also asked to discuss how they could carry out the observing and recording tasks with a class or small group working inside the classroom in future. The teachers completed the questionnaire on confidence and knowledge.

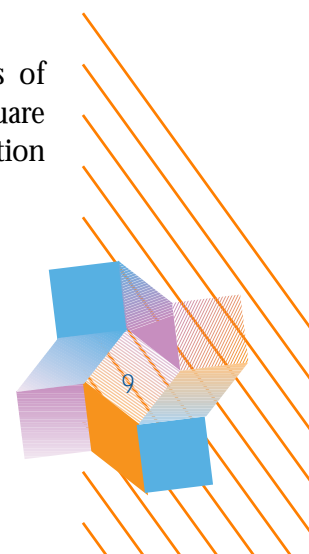
The focus group discussion at the end of the session was led by the consultant. The focus of the discussion was centred on:

1. What have you found easier to do this year?
2. How have you modified your teaching since last year?
3. How have you been surprised by students' learning?
4. Give some examples of how students' spatial thinking has been developing.
5. Give examples of students describing and classifying.
6. What new aspects have you learnt about students' spatial thinking?
7. How would you describe part-whole relationships to another teacher?
8. What do you think is meant by orientation and motion?
9. How would you describe pictorial imagery strategies to another teacher?
10. How do these relate to disembedding or reseeing shapes?
11. What do you think is meant by pattern and dynamic imagery strategies?

Data analysis

The students' data was considered again in terms of percentages of improvement since the last year's pre-intervention assessment. Chi-square tests of significance were used to compare intervention and non-intervention schools.

Attitude data will be compared with the original data.



The 3D test results of the intervention and non-intervention schools will be compared using confidence intervals of the means.

The teachers' focus group discussion will be analysed for common themes and to assess:

- How teachers are internalising the framework.
- Can teachers see students developing and how?
- Are teachers giving more detail and depth when talking about the framework and students' responses?

STUDENT RESULTS

The data from the students' responses on the observing and reporting tasks is given in Table 1. In 2001, the differences between the groups were very significant.

Overall, the intervention schools performed better after six-months delay before retesting for part-whole relationships. However, the difference is not significant using chi-square analyses. There were no differences for orientation and motion. There are several reasons why this may be the case. The overall number of students assessed was smaller than previously. The main reason for this was the Departmental decision that only one group per intervention school should be assessed whereas previously eight students from all classes in the program were assessed. This decision may have meant a sample that was not representative of the whole group. In one of the intervention schools a noticeable drop in the students who had improved had occurred especially in the orientation and motion group (with students moving to private schools or moving from the area) and much of the teaching was from the textbook. It was also noticeable that the non-intervention school teachers were keen teachers and tended to use a great deal of discussion, group work, and hands-on activity already. One of these schools implemented *Count Me Into Space* in the following term and commented that the teaching expected in the program was very similar to what they already implemented (data from facilitator schools). There may have been an effect of the researchers assessing the students in the intervention schools six months later rather than an assessment administered by the class teachers.

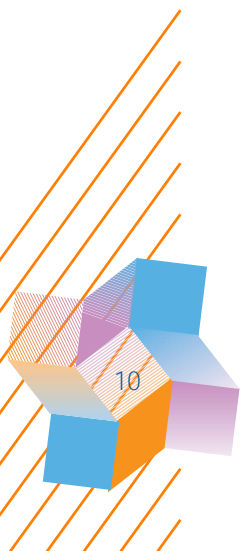
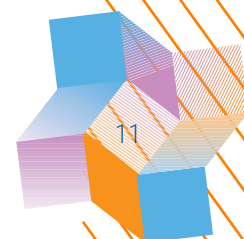


Table 1
Comparison of number of students who improved on assessment tasks

| Task | Number (%) who improved with program | Number (%) who improved without program group | χ^2 value comparing intervention and non-intervention | Number (%) of intervention students who improved on delayed assessment | Number (%) of non-intervention students who improved on delayed assessment | χ^2 value comparing intervention and non-intervention group |
|---------------------------------|--------------------------------------|---|--|--|--|--|
| Part-whole relationships | | | | | | |
| | N = 140 | N = 75 | | N = 64 | N = 62 | |
| Task 1 | 87 (62) | 31 (41) | 8.54 * | 31 (48) | 25 (40) | 0.83 |
| Task 2 | 85 (61) | 25 (33) | 14.65 ** | 43 (67) | 33 (53) | 2.56 |
| Task 3 | 72 (51) | 18 (24) | 15.10 ** | 35 (55) | 34 (55) | 0.00 |
| Task 4A | 74 (53) | 22 (29) | 10.94** | 34 (53) | 25 (40) | 2.07 |
| Task 4B | 84 (60) | 27 (36) | 11.26** | 29 (45) | 20 (32) | 2.26 |
| Three or more tasks | 77 (55) | 20 (27) | 15.83 ** | 39 (61) | 30 (48) | 2.00 |
| All tasks | 19 (14) | 0 (0) | ** | 4 (6) | 4 (6) | |
| Orientation and motion | | | | | | |
| | N = 73 | N = 34 | | N = 37 | N = 34 | |
| Task 1A | 33 (42) | 9 (26) | 4.48 * | 14 (38) | 12 (35) | 0.05 |
| Task 1B | Not included | Not included | | | | |
| Task 2 | 43 (59) | 13 (38) | 3.97 * | 17 (46) | 18 (53) | 0.34 |
| Task 3 | 42 (58) | 9 (26) | 8.97 * | 20 (54) | 17 (50) | 0.12 |
| Task 4 | 44 (60) | 12 (35) | 5.80* | 23 (62) | 27 (79) | (2.53) |
| Task 5 | 38 (52) | 8 (24) | 7.70* | 13 (35) | 12 (35) | 0.00 |
| Three or more tasks | | 37 (51) | 9 (26) | 5.55 * | 16 (43) | 17 (50) |
| All tasks | 8 (11) | 0 (0) | ** | 1 (3) | 4 (12) | 0.33 |

Note. *Difference assessed by chi-square analysis is significant at < 0.05 level and ** significant at < 0.01



CHANGE OVER TIME

For a number of schools, we had a series of data collections over a two-year period. It was expected that while students' maturation and experiences on the tasks meant that students would gradually improve over time, there should be a greater improvement at the time of the intervention. Only the Kindergarten students in 2000 were tracked through to the second intervention. The results for schools that had interventions twice are shown in Table 2 and those for the school who first had no intervention and then intervention are shown in Table 3. The improvement on the second intervention was from the assessment before and after the second intervention. The part-whole assessments were mainly from Year 2 and assessed by the researchers whereas teachers did not necessarily retest the same students in Year 1. These students had not been assessed earlier but were assumed to have participated in the program as they had been at the school during the first intervention.

Table 2
Number and percentage of students improving over two interventions

| Task | Number (%) who improved with program at post assessment | Number (%) who improved with program at delayed assessment | Number (%) who improved with further intervention |
|---------------------------------|---|--|---|
| Part-whole relationships | N = 140 | N = 64 | N = 21 |
| Task 1 | 87 (62) | 31 (48) | 14 (67) |
| Task 2 | 85 (61) | 43 (67) | 14 (67) |
| Task 3 | 72 (51) | 35 (55) | 15 (71) |
| Task 4 A | 74 (53) | 34 (53) | 15 (71) |
| Task 4 B | 84 (60) | 29 (45) | 14 (67) |
| Three or more tasks | 77 (55) | 39 (61) | 16 (76) |
| All tasks | 19 (14) | 4 (6) | 7 (33) |
| Orientation and motion | N = 73 | N = 37 | |
| Task 1A | 33 (42) | 14 (38) | - |
| Task 1B | Not included | | |
| Task 2 | 43 (59) | 17 (46) | - |
| Task 3 | 42 (58) | 20 (54) | - |
| Task 4 | 44 (60) | 23 (62) | - |
| Task 5 | 38 (52) | 13 (35) | - |
| Three or more tasks | 37 (51) | 16 (43) | - |
| All tasks | 8 (11) | 1 (3) | - |

Note. The students who took the Orientation and motion program moved to lessons on angles and so there was no reassessment at the end of the year.



A large percentage (between 50% and 60%) improved after the initial intervention. Without intervention, the percentage that improved on the task dropped slightly except for Task 2 on grids. If students had been using perceptual strategies and positioned the tiles during the earlier assessments, then they are likely to remember the result. The reduction in numbers assessed and the fact that researchers rather than teachers carried out the delayed assessment may have reduced the improvement numbers. With further intervention the percentages that improved on the tasks was around 70%. These students were in Year 1 and had been involved in the program for two years. Besides an increase in age, the intervention at both times had a noticeable effect.

The improvement on Orientation and motion tasks was more diverse. Again percentages after a delay were not much different to the post-intervention. The non-intervention students learned from participating in the task on folding the net. The pyramid task had a larger reduction in improvement after time. The Year 2 students did not follow this program into their third year so no results are available for a second intervention.

It is interesting to compare these results with those from the one school that was originally assessed without intervention and then assessed with intervention. The school had a facilitator to assist with the team teaching during intervention. However, the same cohort is not tracked through this data as none of the students assessed were the same and the numbers in the sample are small. Again the improvements occurred with intervention. This is shown in Table 3.

Table 3
Number and percentage of students who improved with non-intervention and then intervention

| Task | Number (%) who improved without program at post assessment | Number (%) who improved without program at delayed assessment | Number (%) who improved with intervention |
|---------------------------------|--|---|---|
| Part-whole relationships | N = 13 | | |
| | 12 for task 1 | N = 13 | N = 35 |
| Task 1 | 1 (8) | 1 (9) | 21 (70) |
| Task 2 | 3 (23) | 6 (46) | 23 (77) |
| Task 3 | 0 (0) | 4 (.33) | 14 (47) |
| Task 4A | 3 (.23) | 0 (0) | 26 (87) |
| Task 4B | 5 (.36) | 5 (.42) | 24 (80) |
| Three or more tasks | 1 (8) | 3 (23) | 20 (57) |
| All tasks | 0 (0) | 0 (0) | 2 (6) |
| Orientation and motion | N = 6 | N = 7 | N = 17 |
| Task 1A | 1 (14) | 1 (17) | 9 (53) |
| Task 1B | Not included | | 5 (29) |
| Task 2 | 3 (43) | 0 (0) | 12 (71) |
| Task 3 | 3 (43) | 2 (.33) | 9 (53) |
| Task 4 | 2 (29) | 5 (.83) | 8 (47) |
| Task 5 | 2 (29) | 0 (0) | 5 (29) |
| Three or more tasks | 2 (27) | 0 (0) | 11 (65) |
| All tasks | 0 (0) | 0 (0) | 3 (18) |

Implementation over two years with consultancy support



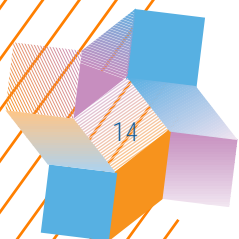
Without intervention improvements on recognising shapes in the environment were less than 10% but with intervention, 70% gained. Without intervention, scores on individual tasks on part-whole relationships varied from no student improving up to nearly 50%. By contrast, after intervention, the scores for both Kindergarten and Year 2 were generally around 80% except for the hidden shape task for which 50% improved. While less than 10% improved without intervention on three or more tasks, 23% continued this improvement on the delayed assessment and considerably more, 60% improved after intervention.

For orientation and motion, the number of students was smaller. Without intervention there was little gain when the researcher tested again, except for the task involving folding the net. The gain for this task was large but it should be remembered that only seven students were involved and students seemed to remember doing this task. By contrast, between 30% and 70% improved on the various orientation and motion tasks after intervention. For improvements on three or more tasks, 30% initially gained, followed by a reduction to 0% on the delayed assessment. However, after the intervention 65% gained (these students had not previously been assessed).

COMPARISON OF SCORES ON THREE-DIMENSIONAL TEST FOR INTERVENTION AND NON-INTERVENTION STUDENTS

Scores on the three-dimensional test after the six months delay were compared for the 30 students in the intervention and 34 students in the non-intervention groups consisting of those students who had pre-test scores and test scores. The students were initially in Year 2. When confidence intervals of the means of scores for the two groups were compared there was considerable overlap. The confidence interval of the mean for the intervention group was 39.5 ± 1.76 whereas the non-intervention group had a confidence interval for the mean of 39 ± 1.9 . The test has items similar to those used for intelligence tests, especially of spatial abilities so this may be influencing results.

However, when the students were broken into three groups according to their pre-treatment scores, there was virtually no overlap for those students in the lowest group. The groups were decided by giving indicative scores of 1 to 4 for the different kinds of strategies and taking an average. Those with an average of 2 or less were placed in the lowest group, 3 or less in the middle group, and 4 or less in the top group. The lowest group of eight students with intervention had confidence intervals for the mean of 38 ± 3.5 and the seven students in the non-intervention group had a confidence interval for the mean of 31 ± 3.5 . Even when the considerably lower test score (22) for one student in the non-intervention group was eliminated as an outlier, there was still little overlap. These results are shown in Figure 1.



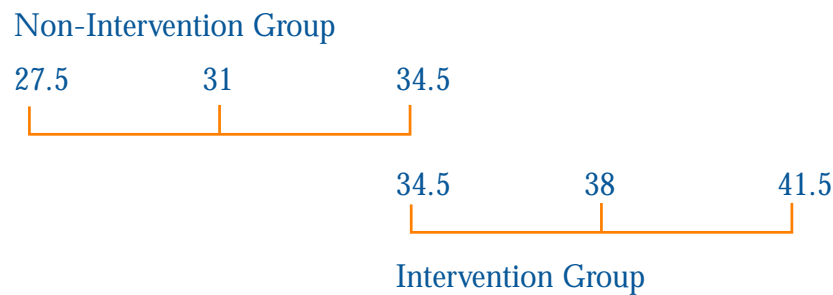


Figure 1. Comparison of confidence intervals of means for scores on 3D test for lowest group of intervention and non-intervention groups.

This confirms the reports by teachers that the weaker students are gaining considerably from the classroom experiences. The group work, discussion and hands-on experiences encourage a sense of ownership of their work and help these students to improve.

CHANGES IN EFFICACY

Bobis (1996) had flagged the importance of efficacy in an earlier report on *Count Me Into Number*. She was not able to show significant effects of the number program using the self-concept instrument that she used.

The current study used questions that were based on a small unpublished project with pre-school students and then the questions were tried with students in other schools. At the start of the program, data was collected from a relatively few students on the assessment day at the intervention schools. Unfortunately, the researchers were not notified of this difficulty early enough to rectify the problem. Hence the comparative data we desired is small. Table 4 combines all students and gives the number of students responding to each of four items on the schedule. The selection was made because the Department wished to restrict the number of questions on this survey for the continuing schools. The researchers noted that on the full questionnaire those students who liked to build and play sport had more positive responses to space mathematics and enjoyed the challenges of space mathematics.

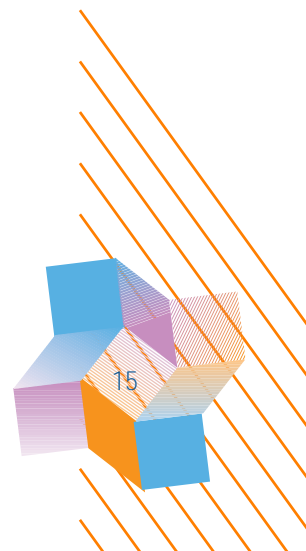
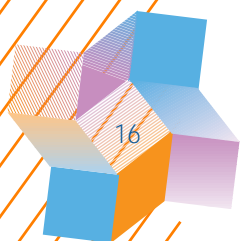


Table 4
Changes in responses to selected questions

| Item and responses | Pre-interview | | Post-interview | | Delayed interview | | After second intervention | |
|--|---------------|------------------|----------------|------------------|-------------------|---------------------------|---------------------------|------------------|
| | Intervention | Non-intervention | Intervention | Non-intervention | Intervention | Non-intervention | Intervention | Non-intervention |
| Are you good at space mathematics? | N = 14 | N = 109 | N = 38 | N = 114 | N = 96 | N = 35 Part-whole only | N = 56 | Not applicable |
| <i>Yes (most or some of the time)</i> | 13(93) | 102(94) | 33(87) | 107(94) | 82(85) | 32(91) | 50(89) | |
| <i>No (most or some of the time)</i> | 1(7) | 7(6) | 5(13) | 7(6) | 14(15) | 3(9) | 6(11) | |
| How do you know? | | | | | | | | |
| <i>Self-determined from what they do</i> | 7(50) | 66(61) | 17(45) | 77(68) | 45(47) | 22(63) | 29(52) | |
| <i>Just know</i> | 4(29) | 11(10) | 6(16) | 9(8) | 22(23) | 4(11) | 14(25) | |
| <i>Verbal approval</i> | 2(14) | 4(4) | 13(34) | 7(6) | 19(20) | 5(14) | 9(16) | |
| <i>Don't know</i> | 0(0) | 7(6) | 3(8) | 7(6) | 13(14) | 11(31) | 7(13) | |
| What do you like best? | | | | | | | | |
| Mental challenge | 2(14) | 10(9) | 5(13) | 17(15) | 7(7) | 1(3) | 2(4) | |
| <i>Specific activity</i> | 7(50) | 26(24) | 35(92) | 36(32) | 47(49) | 28(80) | 27(48) | |
| <i>Social activity, fun</i> | 1(7) | 11(10) | 2(5) | 10(9) | 11(11) | 2(6) | 9(16) | |
| Building, equipment | 3(21) | 62(57) | 4(5) | 50(44) | 17(18) | 1(3) | 10(19) | |
| What do you do when you have difficulties? | | | | | | | Not asked | |
| <i>Think/work it out</i> | 4(29) | 9(8) | 21(55) | 27(24) | 18(19) | 18(51) | | |
| <i>Ask peer</i> | | 1(7) | 16(15) | 10(26) | 9(8) | 9(9) | 3(9) | |
| <i>Ask family</i> | 1(7) | 9(8) | 4(11) | 6(5) | 2(2) | 1(3) | | |
| <i>Ask teacher</i> | 8(57) | 67(61) | 21(55) | 60(53) | 25(26) | 19(54) | | |

Note. Some students gave more than one response to the questions.



With the pre-intervention data lacking, there was no way of checking who had changed during the program. There are no patterns in the above data to illustrate the influence of the program. Only the response of thinking and working out a difficult question increased for the intervention schools compared to the non-intervention schools whereas asking the teacher was reduced. The proportion of the non-intervention group who said they liked specific activities, drawing, and variety increased more than the proportion in the intervention school. This was not matched by an increase in mental challenge for the intervention schools as we may have wished. The number gaining confidence and the number who are more self-aware that they are good at space mathematics does not change. Clearly the lack of pre-intervention data and teachers' lack of understanding of the importance of efficacy has made this data less informative than was expected.

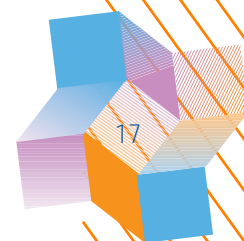
RESPONSES FROM TEACHERS TO OPEN-ENDED QUESTIONNAIRES

There were responses from 14 teachers in three schools.

Some teachers evaluated the material in terms of how it contributed to basic classroom efficiency and saved teachers' time and effort with lessons written out and questions to ask students. Again comments suggested these were a "great guide, good questions", with "easy to follow, clearly written" plans that helped with collecting equipment. Other teachers saw the materials as designed to extend the teachers' capacity to look beyond classroom efficiency and contribute to broader educational goals: "[material] made links to outcomes, lists resources, helped to sequence lessons", "exposed teachers to strategies to teach space and maths", "ideas linked to syllabus documents" and the material offered the foundation for "hands-on" learning by discovery: "[I] read through [the material] first, got equipment organised and then if [I] digressed halfway through, it didn't matter. Great starting place for ideas."

All teachers felt that facilitators (in this case consultants) were needed to some extent. The reasons ranged from "[I] need all the help I can get" to "need to know why teaching particular lessons" and "to have framework explained, and test tasks demonstrated". "Specific problems came up and the language was new and the consultant clarified meaning".

The majority of teachers found the framework was too much to cover in the time given and so was often confusing. Suggestions included spreading the lessons over two terms and having a lesson on each test item. Others found the workload with new lessons that were confusing or moving too fast with new terminology somewhat overwhelming. One teacher commented that the lessons did not suit the developmental level of the students. Some needed more detail in the lessons while some found the work repetitive or their resources inadequate. Another suggestion was to have photographs of students' work "just for inspiration". However, most teachers liked the structure and were generally satisfied as they were able to place students well.



Teachers' responses about assessment were that they would be time-consuming if a whole class were tested and they felt the tasks should be prepared for a group or whole class assessment rather than one-to-one. They also wanted to see more clearly how the lessons fitted in with the assessment tasks.

Although a third of the teachers did not comment on the rest of the written materials, some felt they were very thorough and needed no improving and "definitions were easy enough to understand". The main problems were the amount of reading and technical terms, and the physically unwieldy nature of the kits, for example, lessons should be on one page.

The lesson plans were again well received with comments on clarity, value, good lesson sequence, and use of outcomes, resources and language involved. Some teachers found problems with wordiness.

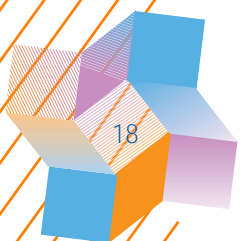
All teachers (except for one who made no comment) saw availability of correct, ready made equipment and plenty of it as important. Some teachers were keen to have equipment made up in boxes by the Department or produced commercially or more proformas, e.g. for jigsaw and silence lessons. Some see a need to get a collection of equipment while other schools said "we have gathered together and stored it [we] now have a good basic kit and add on to it—can be included in basic class equipment". One teacher commented on the time needed to cut out shapes, and one said, money was not the problem but availability was. Interestingly one needed little equipment.

Interestingly one teacher did not watch the videotape (she may have been involved during the previous year), another could not remember its content and another replied it was just introductory and not helpful enough. However, the others found it "gave a clear idea [about] how lessons should develop", "how to implement lessons", and "clarified" instructions. "It helped seeing lessons in action" and gave "confidence". Seeing certainly helped teachers appreciate the content and processes required in the program. When asked how could the videotapes be improved, almost half the teachers made no comment on the videotapes but others made positive comments on clarity and helpfulness. Clearly not all the videotapes were seen and one teacher wanted "more activities to be completed for the teachers to be shown".

Teachers were not always clear about the question on global outcomes but in general they found them appropriate with dot points valuable and links between strategies and outcomes being clear. One teacher suggested, "One specific outcome is enough", probably referring to the lesson plans rather than the framework table.

All teachers responded at some length to discuss how they had changed their teaching with an emphasis on a more hands-on approach and several mentioned language development.

Lessons were in some ways less structured with more incidental learning and small group learning, and more changes in the direction of the lesson



with students dictating how the lesson goes. At the same time, “questions were now more towards what they are doing and why”. One teacher commented on being “much more committed to the value of concrete materials and also opportunities for the students to practise and explain”. Teachers commented on “better understanding of space, and moved away from space lessons just being recognition of shapes” and “more open to various ways to teach certain concepts”. Some responses noted the connection between more structure and more depth of teaching, “[I am] more directed on sequence in my approach to lessons, [and have a] raised awareness of language and expectations of learning”. While organisation of lessons was improved so too were the integrations with art and craft.

Teachers were able to explain how their students were developing understanding about part-whole relationships. Several commented on the benefits of structure and sequence provided by lessons. In one school they “used the foundation gained last year [that] helped students develop understanding this year”, and further experience with different steps (making, cutting, moving, drawing) has helped develop understanding”. The lessons are directed, so “the students are increasingly aware of why and how rather than just accepting an answer”. Several teachers commented on development of students’ skills: “better understanding of properties and 2D/3D shapes”, and “language and greater awareness”, “to see shapes within shapes”, and “developing grid concepts”. One teacher noted his or her own development as “more directed teaching”.

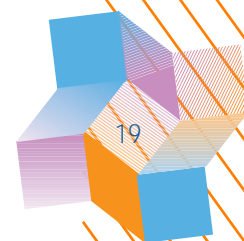
Teachers expected further development through “further investigation and hands-on, for example, with geoboards, tessellating shapes and angles, shapes within shapes, and developing pictorial imagery strategies”. Some saw a need to extend the program to K–12. This way concepts would be reinforced.

Further development would be facilitated by a more organised, timetabled approach and “follow-up with lesson plans repeated and extended over two terms or a large block giving more practice!” Teachers could see the need for a “whole school inservice and for continuity with “folders and evaluation sheets passed on, and kits made available. Some lessons could be redone with more depth or different perspective.

Students and teachers involved with orientation and motion said they “enjoyed and followed instructions more carefully”. Students were able to “view objects and actually see more than just a front view, and appreciated the dynamic of shapes”. Students were “communicating—more confident with use of terms or language”, “stretching shapes, looking at different perspectives”, “using concrete materials”. One commented that there was “a lot of information to take in—perhaps condense or delete some if possible”.

COMMENTS ON LESSONS

Four of the five schools provided lesson registers in which they responded to three questions: (a) what did the students learn within the framework, (b) how was learning facilitated and (c) any other comments.



Some general comments may first be made on the teachers' responses. Many teachers noted that students enjoyed the lessons and successfully learned to name properties of shapes, use language and associate language with spatial orientation, "flip", "slide etc.". The students also learned to visualise, imagine, image, predict and investigate. Manipulating concrete things helped them think in more abstract terms. However some resources were not "concrete" enough for all students' level of motor skills and they had problems working with string, tracing from unstable outlines, drawing accurately etc. Teachers commented that they had to have well-prepared materials and to consider whether students can manage them. They suggested that (a) sometimes materials were too big or too small, (b) the focus of lesson was lost while students cut out shapes, and wondered whether it was better to have shapes ready. Not all students can cope with some of the lessons. There seems to be a developmental level beyond which some cannot go. Some just needed practice at skills such as folding paper to get in touch with the concepts being taught through "hands-on" methods. Enough time is important for the processes of learning by discovery.

Teachers' responses suggest a little confusion with terms such as "framework": the answers to the first question, what is being learned within the framework, tend to wander between looking at what has been specifically taught using the lesson, the teacher's method and the activities of the students, though most teachers point to language skills and recognition of properties as examples of learning within the framework. Some teachers seemed to lose direction if there were problems getting students to catch onto and manage activities.

Part-whole relationships

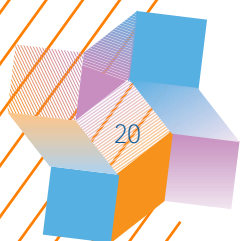
Making pictures with patterns and shapes

This lesson encouraged students to learn about the properties of various shapes, to see shapes within other shapes, and to be more aware of shapes in the environment. In one class teachers modelled the task and talked about different sorts of pictures and reasons for choosing shapes.

It is necessary to suggest to teachers that they have shapes cut out before the lesson rather than waiting for the students to do this.

Jigsaw making

Teachers from one school felt students learnt nothing in terms of the framework from this activity and that they found it hard. On the other hand, teachers at another school found students were recognising that a particular shape, e.g. triangles, could be different shapes and can fit together to form other shapes, e.g. rectangles or squares. This was facilitated by the teacher modelling on the floor and explaining. The students took turns placing shapes. The students enjoyed the lesson and it was interesting to the teacher to find who found the activity easy or challenging.



Radiating painted triangles

Teachers' comments suggest that they found the activity encouraged students to perceive triangles in different orientations and to recognise that not all triangles are equilateral. Teachers asked questions to encourage recognition of parts. Learning seemed to encourage perceptual strategies such as simple language and turning to recognise specific shapes. Interestingly, some teachers focused on learning of ideas such as *radiating* rather than the main purpose of the lesson which was about recognising triangles in different orientations and to notice that triangles need three points or three straight sides.

Shapes in the environment

This activity encouraged students to see shapes in places where they previously had not noticed them and that shapes were everywhere inside and outside. Some older students realised that some shapes are chosen for built objects for reasons, they fit together, add strength, i.e. shapes can serve a purpose—natural shapes are more random. However, teachers noted that students need to distinguish between 2D and 3D shapes and that they saw filled-in shapes more easily than just outlines or framed space.

Making shapes with their bodies

Students were imagining shapes rather than actually seeing them (they had to do this while they were actually forming the shapes) and the students loved it. It was a good break between other lessons. It was good for students to experience shapes, which were not on paper. However, some curved shapes were difficult for them and it was difficult to generate new language from students although the teacher rephrased to model it.

Squares on a geoboard

Students did patterning on the geoboard with squares of varying sizes. Students confused rectangles and squares but could see the difference when shown and learned that each side of the square must have the same number of dots (used dot paper rather than geoboards).

Students enjoyed making the squares on the geoboard and trying to draw on the dot paper although some found it hard.

Cutting up a large triangle

While students in two schools enjoyed the lesson and discovered they could make many triangles of different shapes and sizes, learned about quadrilaterals and reinforced properties of triangles, a teacher in another school found it difficult. One teacher encouraged students to select favourites and to make a class collage. Another teacher noted that there was a need to follow-up terms: quadrilateral, rhombus, trapezium while another commented that there was not enough time to discuss how approaches to cutting and kinds of shapes were made.

This lesson could be written for different Year levels; younger students could simply cut and recognise different shaped triangles and older students could investigate making different shapes by different kinds of cutting.



Triangles on a geoboard

Again students recognised that triangles did not have to be an equilateral triangle. Students saw shapes within shapes, realised they can be made from any part of the geoboard.

Teachers demonstrated how to make varying sizes and styles of triangles first. Students made their own and compared them.

In one class, students were stretching a triangle which gives it a different shape. They found out the need to alter all three points. They counted pegs and tried to reproduce the triangle exactly on paper or on the geoboard when copying a friend's.

Students had difficulty copying triangles onto paper. Dots on paper did not correspond with dots on geoboard. It seems that the advice to use plain paper or be identical to geoboards with the same number of rows and columns has not been passed on.

Teachers were still commenting on the difficulty of handling elastic bands and expressed their concern that students are not very verbal, and tend to "parrot" properties instead of looking for new, interesting, unique things about the shapes.

Triangles with sticks

Made many different 3, 4, 5, and 6-sided shapes. They learned that shapes in different orientations can be made into pictures and that triangles can be in different orientations. They learnt about different properties, e.g. sharp shape, depends on short or long sticks used.

Teachers allowed a lot of group collaboration to construct designs and pictures. One teacher used geostrips and split pins.

Teachers suggested that they need to reinforce names of shapes, quadrilateral, rhombus, trapezium, parallelogram and that students had difficulty seeing new shapes when triangles are combined. Perhaps tracing might assist this disembedding.

Other shapes with sticks

This activity reinforced students' knowledge of properties of shapes. The teacher used pop sticks.

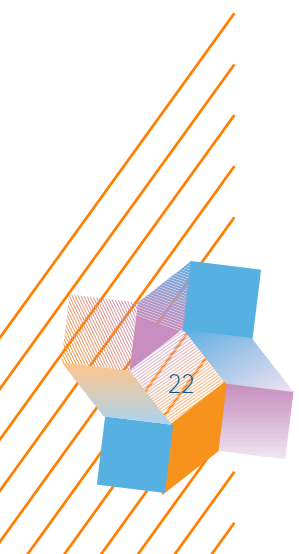
Squares and more squares

Students noted similarities and differences between squares or rectangles and trapeziums. They realised that all four-sided figures are not squares, that four-sided figures do not have to be regular shapes, and all four sides can be different lengths.

It helped to have students working in pairs to discuss and self-correct their attempts at making squares, etc. Elastic bands were still a problem.

Joining and tessellating triangles

Students learnt that triangles can tessellate and make a pattern, triangles can be placed in different orientations. They learnt to flip, slide, turn shapes



to make them fit, to tessellate triangles and make a pattern, to recognise and make triangles in different orientations and they learnt or revised the terms *flip*, *slide* and *turn*. Teachers showed students' work to those who were unsure.

Tessellating squares, rhombuses and rectangles

Students learnt that shapes have to be moved to get them to tessellate, a square can be stretched to make a rhombus, and that the corners are different for a square and a rhombus.

Teachers facilitated this learning by varying the size of the square or rhombus shapes that were provided. One teacher found there were not enough shapes available on this day and used other pattern blocks (rectangles, hexagons).

Orientation and motion

String shapes

Students made shapes in groups of four to five with string and then traced on concrete. They could name many shapes and talk about the lengths of sides and properties of shapes.

It is interesting that teachers felt the shapes had to be traced and they suggested that it would be easier with shorter string on the desk. Another teacher felt the string should be joined. Teachers found the discussion time was valuable and it was useful to revise by walking around drawn shapes. Other suggestions included using large rubber bands and having groups with one giving the properties and the other making the shapes.

Silence

Students learnt to generate images of shapes in a variety of orientations and with different patterns. They learnt to cooperate, discriminate, decide how shapes could fit together and to concentrate. They learnt by looking at others, matching pieces by shape and lines, and imaging a missing shape. Learning was facilitated by group discussion and demonstration.

As a follow on lesson, one teacher had students cut triangles into three and played again. This was much harder, only one clue: match the shapes. There was no line or shading on one side.

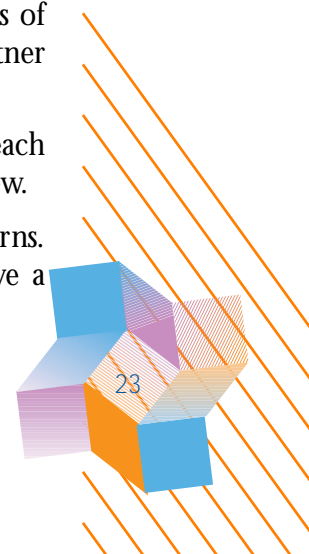
A demonstration lesson with circles was very specific. Students enjoyed making each piece, and all were involved as each had to use visual imaging.

Block building

Students could recognise shapes that match a set image, make images of shapes (only on one plane). Only some made a 3D model. The partner built the model exactly and explained the model.

Teachers facilitated by demonstrating and describing the model to each then drawing out different properties and counting blocks in each view.

Students enjoyed the activity and became good at exactly modelling patterns. It was difficult for students to draw what they saw. They could have a worksheet to fill in for what they saw, side, front, bottom, top.



Memory

Students were able to discuss shape, parts of shapes, and actions on shapes when shapes were present. Little memory was used apparently. The lesson plan was followed carefully and not extended. Students enjoyed the activity and wanted to repeat and make 3D not just flat designs.

One teacher demonstrated the game, talked about what makes up different shapes: curves, corners, points, sides etc.

One teacher suggested that students needed two sets of large shape (even leaves from outside class), and to make each movement clearer.

Paper folding

Students learnt that mathematics involves risk-taking, predicting and practising and visualising to solve problems. Students learnt that a shape was closed but commented that “This is not a real shape” when looking at uncommon shapes or ones with curves.

Teachers had to reassure that “it’s OK to make mistakes, make predictions, and it does not matter if you’re not right all the time”. More instructions were needed, like whether lines could be curved or straight. Then students were more confident and talked a lot.

Make it like mine

Students were learning to modify shapes mentally by using motion analysis. They were using the words “flip”, “slide”, “turn”, and “rotate”. Demonstration, discussion and group collaboration assisted students.

Geoboard symmetry

Students learnt that symmetrical patterns have two sides that are interdependent. Teachers facilitated this by discussing how the two sides of the pattern worked in a kind of partnership with each other, similar to the way the patterns worked during the activity itself. Nevertheless, students had difficulty with elastic bands slipping off the pegs of the geoboard. Teachers needed clarification on where the line of symmetry should be.

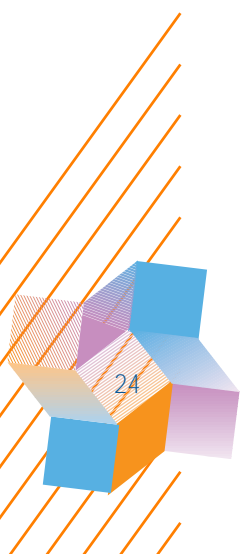
A Fly on the ceiling

Students represented the positions of objects using models or sketches and used everyday language to describe their positions.

The teacher used class discussion about using different materials to construct a “model” of the classroom and then transferring this onto paper, making a map of the classroom. The students found it an excellent, enjoyable lesson, and it encouraged divergent thinking skills. Students could also make models from drawings.

Faces and nets

Students used boxes to name faces, edges, corners of 3D shapes then predicted and investigated the nets of boxes. They were drawing nets of boxes as they thought and predicted the properties and shapes of nets. Teachers tended to follow the notes, and called the class together to explain



procedures at each step. They made good collections of boxes of all shapes and sizes generally, but some noted that box sizes could be too large, some boxes were difficult, tape was needed for joining, and students had to learn to make a good crease to remake the box. It helped to colour each face to show the number of faces. The lesson could be repeated or varied to provide consolidation. Teachers really found that tracing the cardboard, cutting and creasing was much better than giving students the net of a cube to cut out and stick together. They could wrap up then make the folded out net in cardboard.

Making a cylinder and cone

Students could predict changes mentally, using motion or pattern analysis. It was facilitated by class discussion about what would happen if they rolled up a flat piece of paper.

Students found it difficult to visualise and so paper rolls as concrete evidence was needed. Students could identify properties but could not visualise a cylinder or a cone flat, and think of the solid shape as made up of triangles, squares etc. (do teachers know that cones are sectors of circles—put into glossary and as elsewhere direct teachers' attention to the glossary).

Around and around

While students had difficulty verbalising placement of blocks and reconstructing other groups' towers (perhaps because drawings were misleading), they did a good job of drawing. The teacher facilitated the lesson by giving choices when verbally describing positions of the blocks, e.g. under or above or next to etc. Another teacher modelled language carefully, especially that related to drawing. Too late, teachers realised that students should not write names on paper before shuffling (another note for teachers).

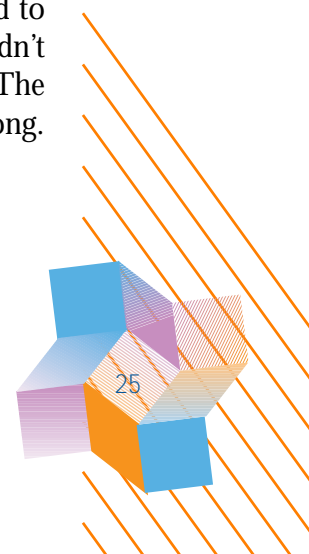
Pattern block symmetry

Students used small pattern block to make symmetrical designs around a line of symmetry on a piece of paper. Teachers demonstrated and explained both with no symmetry and with symmetrical patterns. Language included flip, slide, turn and imagining a mirror. Students enjoyed the lesson and recorded patterns on paper for displays individually.

Guidance is needed on how students can write how a pattern was created.

Shadow shapes

Students investigated shadows from different views of 3D shapes. The teacher demonstrated how to make, and label shapes and emphasised the need to cooperate in groups. Torches were not bright enough and students couldn't hold 3D shapes still long enough to trace. Results were quite messy. The teacher gave a toy to them to trace the shadow. The lesson was quite long.



TEACHERS' FINAL MEETING

The consultants met with a group of teachers in two of the districts. Teachers' comments tended to support the data given in detail above from the teachers' questionnaires and registers. Extra hints on the lessons were given such as including sponges in kits, teachers highlighting important parts of the lesson beforehand, clarifying the faces and flaps of boxes and pressing folds for edges when folding up a net. The string shapes require students to stand outside the shape and hold the string while the outline is traced.

The meeting comments reinforced that teachers are now more practical, that kits provide more ideas, and that teachers are noticing that students are discovering things for themselves and using more space language and explaining how they know. Teachers have higher expectations and are finding students are thinking rather than being "spoon-fed".

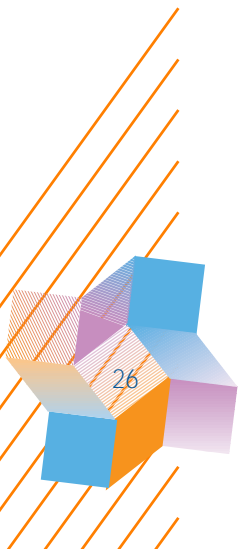
Nevertheless the only comment on what they had learnt about students' spatial thinking was how to use pattern blocks in a more directed manner and that orientation and motion meant turning, flipping, and sliding. The idea of visual imagery was not expressed in teachers' comments. It was implied in comments on specific students' responses to the tasks "When doing paper folding, the more they did the better the students became." In another incident, the student pointed out a triangle as part of a glass pane.

Another scenario was reported:

One student, when shown the net of the open cube and asked to predict what it would be said "a square". After folding the net and explaining how to fold it he was asked, "What have you made?" He replied "a cube with no top". Teacher commented, "Before you folded your cube you told me it was a square. Why did you change its name?" The student said, "Before it was flat so there were squares 'cause squares are flat shapes. Now it's a cube 'cause the squares are standing up and joined and there's space all around it". It pays to probe.

A teacher commented that activities on geoboards and the lesson called *Fly on the ceiling* were in one of the textbooks. Another teacher said they did not do the lesson requiring sand because it required sand despite the proximity to the waterfront.

It is interesting to compare these limited comments on the framework with those used by teachers in schools implementing the program with a facilitator. The teacher talk at regular meetings seems critical.



CONCLUSION

The implementation of the program a second time had benefits for students and teachers. The knowledge learnt in the previous year was consolidated for students. The students improved in their responses to the observing and reporting tasks after intervention. However, gains on delayed assessments were not significantly different to those gained by the non-intervention schools but there are possibly other reasons for this result. There is evidence from the time-series data that intervention was effective. Students' scores on the test *Thinking About 3D Shapes* did not indicate significant difference between the intervention and non-intervention schools except for lower-achieving students. Data on students' confidence was limited.

Implementing the program a second time has increased teachers' comfort with the lessons and the purpose for the lessons. The teachers gave positive comments on the lesson plans. Based on teachers' comments, in general, the intention of the lesson was clear to the teachers. They were generally able to modify them to suit their situation. Some care may be necessary to improve teachers' knowledge. Some improvements can be made to link the framework, assessment tasks, and lessons more closely. Some lessons need to be split into two investigative lessons.

The teachers have changed their teaching and discuss this in terms of purpose, hands-on activities, and discussion. The ideas like part-whole relationships and the notions of changes in representations of shapes by movement are discussed in more depth with the students. Teachers have enjoyed the students' enjoyment during the lessons.

