MATHEMATICS: MORE TIME, MORE TICKS!

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The Harristown State High School project investigated the effect of more time via voluntary after-school, core mathematics tutorials on Year 8 student learning outcomes. Six factors (additional time, assessment structure, colour booklets, supportive learning environment, rewarded competitions and qualified tutors) were identified from a pilot study as critical and were chosen to be central to the study. Pleasing outcomes included strong parental support, the number of student volunteers (115), and improved confidence and test results.

Different groups of students learn in different ways and for different individuals the drive to succeed in the quest for knowledge and understanding varies in both strength and source. In countries such as Japan and Korea, noted for outstanding performance in global comparative mathematics assessment (Australian Council for Educational Research 1994; Wu 1999), the immediate and extended family play a crucial role in nurturing this drive to succeed by setting high expectations, taking interest in and supporting students. Western countries differ in that parents and extended families increasingly spend less time with children and provide less structure and guidance to children compared with previous generations (Kane 1994; Stevenson & Nerison-Low 4/20/1999). In the United States, many families where both parents work or the child is living with a single parent who works, much of the child's discretionary time is unsupervised (Task Force on Youth Development and Community Affairs 1992). Similar trends exist at Harristown State High School (HSHS).

Educational research in mathematics has demonstrated a strong link between performance and the time spent studying and revising. A study by Keith (1982) found that the grades of low-ability secondary school students who did ten hours or more of homework and study per week were as good as the grades of high-ability students who did no extra work outside of the classroom. The Carnegie Council on Adolescent Development also noted that a Japanese student spends over 400% more time studying than an American counterpart (Task Force on Youth Development and Community Affairs 1992). For many Junior students at HSHS the comparison is even less favourable. Students do want to succeed (Mamary 1997, 1999) and if given appropriate opportunities will voluntarily extend their school day to spend more time doing mathematics. Students experiencing difficulty in mathematics do not like to be always identified for withdrawal and remediation purposes but often like to work with a mix of other students of varying abilities.

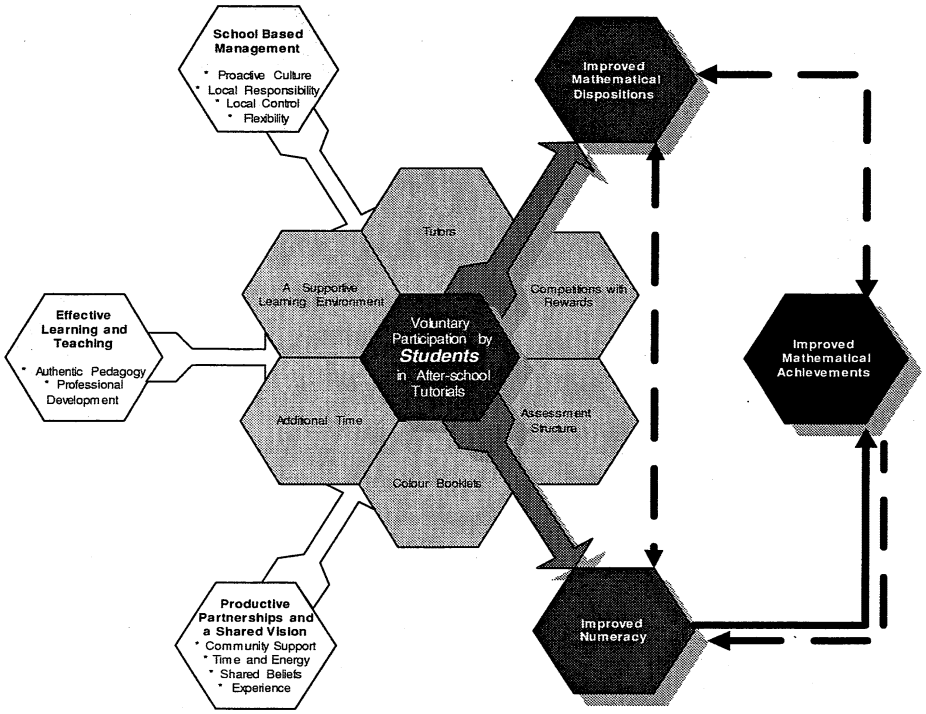
Adolescent development in Asian countries is influenced significantly through activities run at school in a school day of considerably greater length than that in Western Countries. In comparison, in Western Countries such as America, adolescents spend almost one third of their waking time with friends, suggesting that peer-interactions significantly influence adolescent development (Fuligni & Stevenson 1993). The problem for Western teachers and educators would seem to be the ability to develop innovative practices that encourage adolescents to voluntarily incorporate significant learning activities as part of their discretionary time. This, it appears, will only occur if friends and peer interactions are basic to the learning activity.

At HSHS, one particular issue is how to assist Year 8 students achieve improved outcomes in mathematics. Previous experience provided the impetus for a solution. In Term 1 of

1998, weekly two-hour night tutorials for senior mathematics students were begun in a context of competition. As one of three state high schools competing for clientele amongst eleven private secondary schools within Toowoomba, the provision of these tutorials compares with programs offered by the private schools for boarders. These tutorials were completely unstructured and driven by individual student problems and questions. In Term 2 this strategy was tentatively trialed with Year 9 students on a more structured basis commensurate with general cooperative learning principles (Johnson & Johnson 4/29/ 1999; Burnett 1995). The tutorials were student-centred and involved authentic learning opportunities (NCTM 1998; Scott 4/20/1999; Newmann & Wehlage 1995). Evidence of improved student participation and learning as a result of these tutorials appeared to be similar to that found in previous cooperative learning research (Balkcom 1992). However, the popularity of the HSHS Year program exceeded all expectations. High participation rates and many improved scores together with positive attitudes were replicated. Evaluation endeavoured to identify, and in some cases quantify important curriculum and organisational aspects of the Year 9 project. These aspects together with support structures and expected outcomes and their interrelationships are summarized in Figure 1 below.

Figure 1

Relationships between Key Inputs, Features and Outcomes of the Project.



To be able to measure the effectiveness of a similar Year 8 program, the subject of this study, the following key and subsidiary research questions were formulated for investigation.

Key Research Question - In what ways and to what extent does the voluntary after-school program result in increased student achievements in mathematics? Specific factors underlying this question include additional time, assessment structure, colour booklets, a supportive learning environment, competitions with rewards and tutors.

Subsidiary Research Question - In what ways and to what extent does the voluntary after-school program affect student mathematical dispositions?

Method

Approximately 90 Year 8 students initially volunteered to participate in the program. This number swelled to 115 within the first fortnight as favourable student and parent comments spread. Numbers stabilised in the range of 90 to 100 students for the Term 3 tutorials. Term 4 tutorials had an average attendance of about 70 students.

The timeline of the study is presented in Figure 2 below. It extends over the ten weeks of Term 4, 1998 showing when the tutorials and assessments were conducted and when permission letters were issued. Also shown are the times of the student and parent surveys and focus group discussions.

Figure 2
HSHS Year 8 Project Timeline

	Term 4 1998									
School Week	1	2	3	4	5	6	7	8	9	10
Date	7-9 Oct	14 Oct	21 Oct	28 Oct	4 Nov	11 Nov	18 Nov	25 Nov	30 Nov	7-10 Dec
Program		◄ Term3 Tute	Term3 Tute Study 1	Term3 Tute ►		◄ Term4 Tute	Term4 Tute Study 2	Term4 Tute ►		
Assessment (Tests)					Term 3 Resit				Term 4	
Publicity	Assembly, In-class & Letters to Parents				Letters to Parents					
Surveys		Survey One - Study 1				Survey One- Study 2		Survey Two		Parents-Phone Survey
Focus Group Discussions								Tutors		Sample Staff & Students

Two sets of tutorials named Study 1 and Study 2 in this paper were organised for after school from 3:15 pm to 4:45 pm each Wednesday. The Term 3 and Term 4 tutorials covered Term 3 and Term 4 material respectively, yielding 4.5 hours of extra time for each. The Term 3 sessions reviewed Term 3. Students were then given an opportunity to resit the Term 3 test, if they had failed previously, and so a chance to upgrade their result. In the Term 4 sessions, the material for Term 4 was reviewed during the latter half of Term 4 in preparation for the Term 4 test.

The tutorials allowed timetabled classes to operate without segregation. Further, the tutorials utilised some important aspects of cooperative learning involving individual, small group and large group activities. Organisers of the program endeavoured to:

- provide a voluntary learning opportunity that is appealing;
- utilise University of Southern Queensland students as tutors and role models;
- strengthen the social aspect of 'doing maths' incorporating 'friendship groups';
- make spending time on maths socially acceptable and 'normal' for Year 8 students;
- extend the contact time available to students by 1.5 hours per week;

- provide a catalyst for the substantive conversation that fosters higher order thinking;
- show students the link between success and time on task;
- help students learn how to learn.

Each tutorial began with a brief, whole-group focus activity. Participants then broke into smaller groups of about ten students, each led by one of the ten tutors. Each tutor's brief was to promote a supportive working environment that was friendly and conducive to learning maths. The tutor guided the students through the specially prepared, review material. A couple of competitions involving the whole group added variety and interest during each session. The tutorials concluded with a whole-group pep talk on strategies for, and the importance of, the frequency of review.

The teacher/coordinator wrote the review booklets and was responsible for the general organisation and success of the program. She conducted the whole-group sessions, including the interactive review competitions on selected mathematical topics. Also, the coordinator acted as a freelance tutor, encouraging on-task behaviour, reassuring mathematically anxious students and promoting the program at Year 8 assemblies.

Booklets written were based on the core topic objectives and consisted of key concepts and procedures presented in a colourful, clear and easy-to-read format. The text was not used as a source of ideas, examples, questions or tasks so that the teachers' autonomy within the classroom was not compromised. Key concepts and facts were identified and summarised in coloured 'clouds of knowledge'. Recall of these was fundamental to success in the competitions. No worked solutions were given. Rather students and peers helped those with difficulties to complete the skeletal outlines to important facts, generalisations and problems. Students were encouraged to write their own summaries of work on the facing pages as well as rework problems and pose related problems for their peers to solve. Not only did the booklets help students in their revision, allowing them to work at different rates and aiding their organisation, but also allowed the tutors to rapidly obtain an overview and knowledge of the depth of treatment.

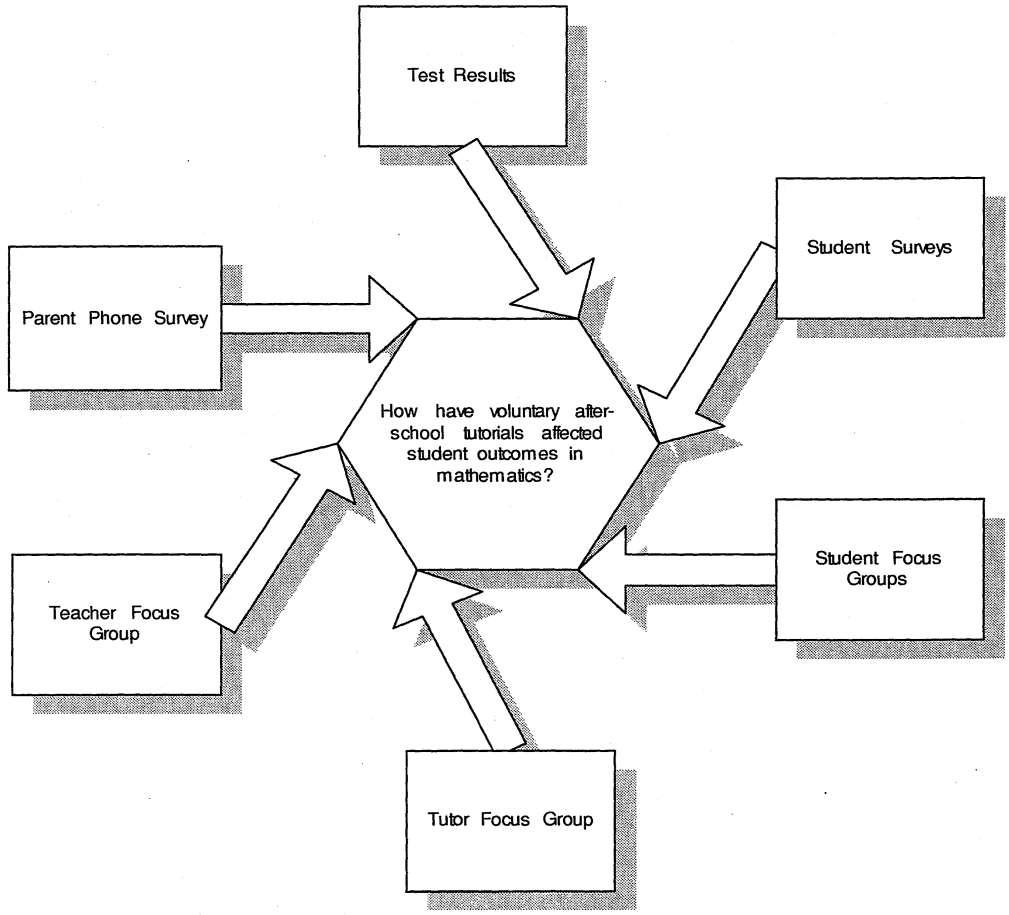
Rewards were instigated to motivate and encourage students to recall reviewed material accurately and quickly. At a school assembly, the Year 8s witnessed the presentation of major prizes (walkmans) to those Year 9s who had participated in the pilot program and had achieved greater than a 35% improvement on their test results. The coordinator confirmed a similar reward system would operate for the Year 8s. Within the tutorials, prizes of mini-sized chocolate bars were awarded to individuals and groups for success in the oral quizzes. These group competitions helped forge a group identity.

Since participation by students in the program was voluntary, a friendly and enjoyable working environment was more easily established. The use of friendship groups, peer tutoring, one-on-one tutoring, sharing of ideas, and many successful, mathematical experiences were all encouraged and facilitated by the tutors. In fact, they became leaders of their groups and acted as role models, promoting a positive and enthusiastic learning environment. Many students could now see that working mathematically need not be a chore but could be enjoyable, even a social event!

Results

The research design of the Year 8 program is presented in Figure 3. It shows the sources of information used to answer the research question, *How have voluntary after-school tutorials affected student outcomes in mathematics?* Both quantitative and qualitative data are used. Analyses of the results of the tests enabled judgement to be made on the extent of improvement or otherwise in student achievement in mathematics. Feedback from the surveys and focus-group sessions provided information on mathematical dispositions.

Figure 3
HSHS Year 8 Project Research Design



Study 1. Study 1 focused on Term 3 (T3) work. For the purposes of analyses, students were grouped according to attendance. Those students who attended all three tutorials and sat the resit test are labelled Group A (n=56); those who attended twice and sat this test are labelled Group B (n=21) while those who attended just once and sat this test are labelled Group C (n=6). The three groups together are called the Whole Group (n=83). *All Year 8s* refers to all students in Year 8 (N=284). Not all students attending the tutorials of Study 1 resat the test (n=32) and these students have been included in *All Year 8s*. The resit test was the same paper as the original test, however, two months elapsed before students sat the resit test. The means of the test scores of these groups are reported in Table 1.

Table 1
Term 3 Test Results by Student Group

Student Groups	T3 Test Mean (%)	T3 Resit Mean (%)	Failed T3 Test Mean (%)	Failed T3 Test Mean (%)	Failed T3 Test Pass Resit (%)
Group A	45.0	50.9	30.5	38.6	26.5
Group B	45.4	52.9	33.0	43.8	33.3
Group C	52.7	53.7	38.3	42.0	16.7
Whole Group	45.6	51.6	31.6	40.1	26.9
All Year 8s	49.0	-	30.1	-	-

Of interest are the results of Group A. On the resit, this group increased their mean by about 6% on the T3 test scores. The Whole Group made a similar gain. On average, this latter group scored below all the Year 8s on the original test but after participating in the program were able to exceed the average on the T3 Resit test scores.

Of special interest are those students who had failed the T3 test for these students had an opportunity to have a failing grade upgraded to a pass. The mean results of these students on the two tests are presented in Table 1, grouped as before. Group A achieved an 8% gain with just over a quarter of the students who failed the T3 Test now passing the resit test. The Whole Group obtained similar results. It is worth noting that the gain for Group C was only about half that for Group A and that only one of the six students in Group C passed the resit test. It appears that frequency of tutorial participation was a major factor in increased achievement by many students.

The absolute and relative increases on the T3 resit test by Groups A, B and C and the Whole Group are presented in Table 2. An absolute increase of at least 20% of the total mark was investigated as the Project team considered that a gain of 10 or more marks out of 50 represented excellent progress. Almost one third of the students in Group A and one quarter of the Whole Group achieved this benchmark.

Table 2
Term 3 Absolute and Relative Increases by Groups of Students

GROUPS OF STUDENTS	T3 Absolute Increase Personal Improvement	T3 Relative Increase Personal Improvement	
	At least 20%	At least 20%	At least 100%
Group A	32.4	79.4	17.6
Group B	20.0	45.0	5.0
Group C	0.0	16.7	0.0
Whole Group	25.0	61.7	11.7

The relative increase was defined as the proportion by which students have changed their original scores. Once again the benchmark was set at a 20% or better increase on the test scores. A 20% relative gain would be less significant than a 20% absolute gain, however, it was considered to be still a substantial achievement. Almost 80% of the students in Group A attained this benchmark, as did about 60% of the Whole Group. Of some interest was the number of students who were able to at least double their initial test score. This doubling would yield an increase of, at least, a grade level. One in six students in Group A and about 12 percent overall achieved this distinction. Comparisons of both the absolute and relative columns indicate that achievements rose the most for students participating in more tutorials.

Study 2. Study 2 focused on Term 4 (T4) work. As in Study 1, students in Study 2 are divided into three groups according to the number of tutorials attended. Group X (n=54) attended three tutorials, Group Y (n=30) two and Group Z (n=31) one. The three groups together are labelled the Whole Group (n=115). The Control Group (n=169) consisted of those students who did not attend any of the tutorials. The results of Study 2 are reported in Table 3.

Table 3
Means of Terms 3 and 4 Test Scores and Relative Personal Improvement by Groups

Student Groups	All Mean T3 (%)	All Mean T4 (%)	Failed T3 Mean T3 (%)	Failed T3 Mean T4 (%)	Relative Personal Improvement	
					At least 20%	At least 100%
Group X	49.2	62.1	29.6	45.0	57.4	7.4
Group Y	48.3	55.2	34.3	43.6	46.7	13.3
Group Z	35.9	42.2	30.2	37.0	45.2	6.5
Whole Group	45.5	55.2	31.1	41.8	51.3	8.7
Control Gp.	51.7	53.7	29.1	36.6	23.7	4.1

The Term 4 test means for all groups increased on those of the Term 3 test, the greatest gain being achieved by Group X. The Whole Group achieved a gain in mean of almost 10% whilst that of the Control Group was only 2%. In term 3, the Group X mean was 49.2%, below the Control Group mean of 51.7%. In the Term 4 test the Group X mean exceeded the Control Group mean by about 8%. Of interest were those students who had failed the Term 3 test. Their average gain on the Term 4 test is 15.4%, more than double that for the Control Group. Of even greater interest were the number of students who had a personal improvement of at least 20% on their Term 4 test scores as compared with their Term 3 test scores. Group X did best with approximately 57% achieving this benchmark, while about 51% of the Whole Group did so. This is more than double the 23.7% of the Control Group.

Surveys and focus groups were used to gather data on the factors underlying the research questions. The six underlying factors (Figure 1) were all supported with both tutor and friends seemingly crucial to the success of the tutorials. Nearly all the participants rated the booklets useful to very useful. Some interesting results were found concerning the amount of out-of-school time spent on mathematics (Figure 4). Over two thirds of the participants reported that they spent more time on mathematics each week during fourth term. However, some spent less time because they were able to work more effectively as a result of the tutorials. Parents in the phone survey supported this.

Responses to the student surveys indicated that the tutorials helped increase students' confidence in doing mathematics. The data is displayed in Figure 5. Eighty-five percent of students felt more confident about the maths topics studied.

Figure 4
Percentage of Students Spending More Time on Maths in Term 4

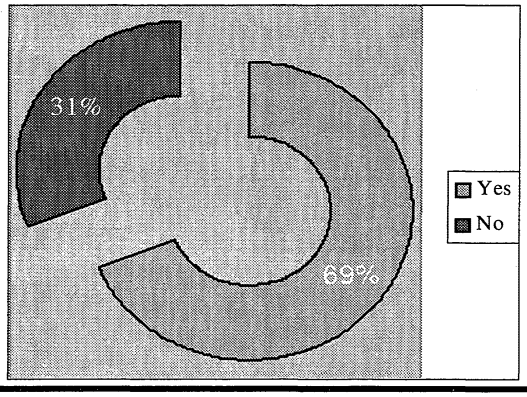
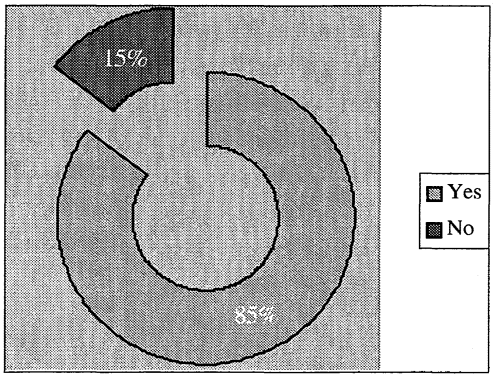


Figure 5
Percentage of Studentswith Improved Confidence in Maths



CONCLUSION

The Year 8 voluntary, after-school tutorial program in core mathematics attracted a most pleasing number of students who wished to improve their mathematical results. A high percentage of these students participated in all six sessions or, because of a severe electrical storm, missed just one.

As expected, in both Studies 1 and 2 those students who improved the most were those who had the most to gain, that is, those who had failed the Term 3 test. Furthermore, the students who attended all or nearly all the set tutorials achieved the best. Their personal improvement was also greater than those who attended only one of the sessions.

The results from the research vindicated the importance of the specific factors identified in the Key Research Question. Each of these had an important influence on student learning/ achievement. The extent and degree varied between individuals.

Several unexpected outcomes have been noted as a result of the project. It has helped to enhance the image of the Mathematics Department and that of the school generally. Many students who gained in confidence have started the new school year with a more positive attitude to mathematics.

The project team is encouraged by the gains in student achievement and confidence, and by the continuing support of students as well as parents in 1999.

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