Self-efficacy and mathematics: Yesterday's students and tomorrow's teachers

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The long-term purpose of the Mathematics for Initial Teacher Education Students (MITES) project, is to develop strategies to improve the levels of self-efficacy and mathematics achievement among teacher education students so that these students have a positive influence on the mathematics education of school students when they enter the teaching profession. The purpose of the first stage of this research is to identify the incoming levels of self-efficacy and achievement in mathematics of first year education students at a Queensland university and to evaluate a programme being developed using co-operative learning methods intended to improve performances on the dependent variables. This paper reports the background and design of the study in progress, the development of the instruments used to test levels of self-efficacy

and the initial results.

Self-efficacy and mathematics: Yesterday's students and tomorrow's teachers

Over several years, concern about the difficulty that first year teacher education students had with basic mathematical concepts in their Mathematics Curriculum course in first year developed among staff at a university in Queensland. The problems that students had with understanding and applying very basic concepts as well as what appeared to be equally poor levels of self-efficacy associated with mathematics,

were not confined to small groups of students or to isolated years. The problems were ongoing from year to year and involved a high proportion of students who had difficulty achieving in mathematics. Clearly, two questions emerged: What was the extent of the problem with students' incoming levels of self-efficacy and achievement in mathematics? and What could be done at university to address these difficulties? In order to answer these questions and to develop and monitor strategies to overcome these problems, a study consisting of several stages needed to be planned. The first stage involved determining the extent of the problems that students were experiencing. At the same time, reliable tests needed to be developed in order that the initial assessments could be made.

Students who demonstrate difficulties with Mathematics Curriculum courses based on primary school mathematics at first year university level or who have low levels of self-efficacy in relation to mathematics may do so for a variety of reasons. Regardless of how well they performed in senior school mathematics in the final years of high school, it is still some years since these students worked with many of the basic, primary-level concepts. Additionally, some students may have misconceptions about particular mathematical concepts and these concepts may need to be clarified for those students. The connection between self-efficacy and achievement has been investigated in other studies and the evidence so far supports the theory that the link between the learning environment and achievement is not direct, but is mediated by self-efficacy (Moriarty, Douglas, Hattie & Punch, 1995). This research will provide further opportunity to test this theory, which merges Bandura's (1986) theory on self-efficacy with current research findings on learning environments, beginning with the Johnson, Maruyama, Johnson, Nelson and Skon (1981) meta-analysis on the effects of aspects of the learning environment on achievement and proceeding through the subsequent debate and later research. In approaching this study, it is recognised that one of the main variables that lecturers in mathematics have control over is the learning environment, which can be manipulated to permit all students to experience success, thus making it likely that their levels of self-efficacy will be increased

and, in turn, their levels of achievement. While this theoretical framework underpins the planning of the present study, this paper is concerned with the first part of the initial stage of the study. The section on methods provides information about the participants and the pre-tests on self-efficacy and achievement, while the construction and psychometric characteristics of the pre-tests are explained separately. The results of the pre-tests deal with the descriptive statistics and reliabilities, as well as the results on the dependent variables in the pre-testing.

Methods

This study is being implemented across four campuses of a regional university in Queensland and has involved most of the first year 1995 Bachelor of Education students in the Faculty of Education. One hundred and fifty-nine students who agreed to participate in the study were given pre-tests of self-efficacy and achievement in mathematics at the commencement of the academic year. These tests were based on the primary mathematics syllabus with questions on the self-efficacy scales paralleling those on the achievement scales. The self-efficacy and achievement scales sampled the areas of Terms, Whole numbers, Measurement, Fractions and Space. The self-efficacy scales were administered immediately prior to the achievement scales so that self-efficacy levels would not be related to the perceived difficulty of the achievement scales. Table 1 is a summary distribution of students tested across campuses.

Table 1: Summary of distribution of participants across campuses

CampusNumber
A90
B11
C32
D26
Total159

MalesFemales
18118

The students were permitted up to one hour to complete all the pre-tests, although most were able to finish well within this time. Only the students on Campus D were then given the option of taking part in an intervention programme designed to increase levels of self-efficacy and achievement in mathematics. The other students would then be the control group. This aspect of the study is not dealt with in this paper.

Construction and psychometric characteristics of the pre-tests

The self-efficacy scales were based on a 6-point response format and directly related to the concepts tested in the achievement scales.

Table 2 shows the corresponding verbal descriptions and numerical values on the scales.

Table 2: Response format for the self-efficacy questions

1 =Not very confident at all
2=Only just confident
3=Reasonably confident
4=Very confident
5=Extra confident
6=Super confident

The six-point response format was chosen because it was small enough for each response to have a meaningful descriptor, both on its own and in relation to the other descriptors and large enough to encourage discrimination. An even number of choices was less likely to promote more thought before responding and more likely to discourage a possible tendency to check the middle of the scale. This type of approach has been used before on similar self-efficacy scales (Moriarty, Douglas, Hattie & Punch, 1995). Each question was marked on a scale from 1 to 6. There were five self-efficacy scales. The number of items per scale are listed in Table 3.

Table 3: Self-efficacy scales administered as pre-tests

ScalesNumber of items
Terms7
Whole numbers5
Measurement11
Fractions 4
Space4

The first pre-test scale on self-efficacy (Terms) is reproduced below to show how the scale was presented to the students.

1.In your maths classes when you were in primary school you worked with a number of mathematical concepts. Please indicate below how confident you feel with your current understanding of each of the following concepts. *

	1	2	3	4	5	6
composite angle						
multiple						
obtuse angle						
isoseles triangle						
parrallelogram						
perpendicular						
hectare						

The response descriptors (shown in Table 2) were provided at the bottom of each page.
The pre-test of mathematics achievement also contained five scales, corresponding to the self-efficacy scales. Table 4 is a summary of the number of items per scale for achievement.

Table 4: Achievement scales administered as pre-tests

Scales	Number of items
Terms	6
Whole numbers	10
Measurement	15
Fractions	20
Space	5

Each item was marked 1 if correct and 0 if incorrect.

Results of the pre-tests
Descriptive statistics and reliabilities.
The descriptive statistics for the pre-test scales of self-efficacy are shown on Table 5. The responses for each sub-scale, while ranging from not very confident at all to super confident, tended to cluster more around the middle (reasonably confident to very confident).

Table 5: Descriptive statistics for the pre-tests of self-efficacy

	Mean	SD	Range
Terms	3.20	1.21	1-6
Whole numbers	4.34	1.14	1-6
Measurement	4.21	1.22	1-6
Fractions	3.53	1.25	1-6
Space	2.96	1.35	1-6

The descriptive statistics for the corresponding pre-test scales of achievement, shown on Table 6, indicate the mean score on each sub-scale.

Table 6: Descriptive statistics for the pretests of achievement

	Mean	SD	Range
Terms	.29	.22	0-1
Whole numbers	.67	.21	0-1
Measurement	.48	.21	0-1
Fractions	.54	.19	0-1
Space	.39	.29	0-1

The results on Tables 5 and 6 relate to the scores of all students

across all campuses.

In order to determine the efficacy of each scale and how well the items and scales worked, reliability analyses were carried out. The results, shown on Table 7, indicate that the scales, particularly self-efficacy, worked well overall, with most items contributing.

Table 7: Reliability analyses for the self-efficacy and achievement scales

Scale	Self-efficacy Alpha	Achievement Alpha
Terms	.88	.50
Whole numbers	.88	.66
Measurement	.97	.74
Fractions	.94	.80
Space	.97	.58

An examination of Table 7 indicates that the reliability of each self-efficacy scale was higher than the reliability of the corresponding scale for achievement. While all self-efficacy scales performed well, two of the scales measuring achievement (Terms and Space) produced reliabilities only commensurate with most classroom tests. It would be expected, however, that the self-efficacy scales would yield higher reliabilities, as this is typical of attitudinal scales. Even so, the levels were very good.

The corrected item-total correlations for each item on each scale of self-efficacy and achievement, as well as the alpha levels of the scales if any particular items were omitted, were calculated. An examination of the results indicate that the self-efficacy scales have only a few isolated items with relatively low corrected item-total correlations but that these items need not be omitted because the overall reliabilities are still high and omitting any particular item would not make very much difference. The resulting overall reliability for each achievement scale would also not alter much if any lesswell performing items were omitted.

Two other possibilities could be investigated in relation to the reliabilities on the achievement scales. One is that the items could be examined at face value to determine the existence of any obvious reasons why those items might perform relatively poorly. The wording of the items, for example, may need to be improved. Secondly, the SpearmanBrown formula could be applied to those achievement scales with low reliabilities to calculate whether using twice or three times the number of items similar to those already included, would raise the reliabilities. Using scales with more items would be acceptable because it would be most unlikely to lead to fatigue among adult students which, if present, could counter the effects of the longer scales.

The results of the pre-tests are considered in the next section of this paper. ANOVAs to test for differences between the performances of the

students on the different campuses and between male and female students overall on each of the scales of self-efficacy and achievement were conducted. Prior to this, Univariate Tests for Homogeneity of Dispersion Matrices were implemented in order to determine whether it was appropriate to proceed with the ANOVAs. Finally, the correlations between performances on the self-efficacy scales and the corresponding achievement scales were calculated.

Results on the dependent variables.

Univariate Homogeneity of Variance Tests were conducted for each self-efficacy and achievement scale. The results showed the need for very little concern, with each test producing an approximate p-value >0.05 on either Cochran's or the Bartlett-Box or both, except for the achievement test on fractions, in which both tests reported a p-value below 0.05. It was, therefore, considered appropriate to proceed with the ANOVAs, first testing for differences between campuses and secondly, differences between males and females across all campuses combined.

Table 8: Multivariate and Univariate Tests for Results Across Campuses

Multivariate Test of Significance

Test name	Value	Approx. F	Sig. of F
Wilks	.70	1.57	.03

Univariate F-Tests (df = 1,133)

Variable	F	Sig. of F
Terms (SE)	1.06	.37
Whole numbers (SE)	3.82	.01
Measurement (SE)	.22	.88
Fractions (SE)	3.97	.01*
Space (SE)	1.43	.24
Terms (Ach.)	1.18	.32
Whole numbers (Ach.)	.52	.67
Measurement (Ach.)	.36	.78
Fractions (Ach.)	.38	.77
Space (Ach.)	1.89	.13

Means and Standard Deviations

Campus	A	B	C	D
N	84	111	72	5

VariableMSDMSDMSDMSD
Terms (SE)3.281.253.130.832.701.633.221.00
Whole numbers (SE)4.541.054.490.973.721.233.981.14
Measurement (SE)4.281.204.191.104.011.474.231.22
Fractions (SE)3.781.233.250.982.821.273.231.07
Space (SE)3.051.412.660.932.351.582.931.04
Terms (Ach.)0.310.230.330.210.240.220.250.17
Whole numbers (Ach.)0.680.200.740.090.650.280.650.21
Measurement (Ach.)0.500.220.440.180.480.220.460.18
Fractions (Ach.)0.530.200.580.200.560.130.530.18
Space (Ach.)0.350.280.460.280.410.320.500.27

SE:Selfefficacy
Ach.:Achievement

Table 8 shows that the MANOVA for the pretests produced a Wilks Lambda of .70, converting to an approximate F of 1.57 and a pvalue of .03, indicating a significant difference across campuses on at least one dependent variable. An examination of the univariate F-tests indicated that the only significant difference between campuses was on the achievement test on fractions, with the students on Campus A having a significantly higher mean than the students on Campus C.

Table 9: Multivariate and Univariate Tests for Gender

Multivariate Test of Significance

Test nameValueApprox. FSig. of F
Wilks.93.93.51
Univariate F-Tests (df = 1,134)

VariableFSig. of F
Terms (SE)1.76.19
Whole numbers (SE).03.87
Measurement (SE).21.65
Fractions (SE).01.91
Space (SE).53.47
Terms (Ach.)2.18.14
Whole numbers (Ach.).02.89
Measurement (Ach.)3.17.08
Fractions (Ach.).01.93
Space (Ach.).64.43

Means and Standard Deviations

MaleFemale
N18118

VariableMSDMSD
Terms (SE)3.521.443.111.19
Whole numbers (SE)4.281.294.331.09
Measurement (SE)4.341.304.201.21
Fractions (SE)3.491.453.521.21
Space (SE)3.111.672.861.29
Terms (Ach.)0.360.260.280.21
Whole numbers (Ach.)0.680.220.670.21
Measurement (Ach.)0.560.240.470.20
Fractions (Ach.)0.530.280.540.17
Space (Ach.)0.440.310.390.28

SE:Selfefficacy
Ach.:Achievement

Table 9 shows that the MANOVA for the pretests produced a Wilks Lambda of .93, converting to an F of .93 and a pvalue of .51. This result indicated that there were no significant differences between males and females on any of the dependent variables. Accordingly, an examination of the univariate F-tests also indicated no significant differences across sexes.

Finally, the correlation co-efficients on the result for each self-efficacy scale and its corresponding achievement scale was calculated. Table 10 shows these results.

Table 10: Correlation co-efficients

Achievement
Self-efficacyTermsWholeMeasureFractionsSpace
Terms.39
Whole .48
Measure.48
Fractions.37
Space.25

The correlation coefficients are interesting because they relate to the correlation between students' levels of self-efficacy and achievement on each corresponding scale measuring performances on the dependent variables. Even though the correlations are all positive, indicating that high levels of self-efficacy are associated with high levels of achievement, the relationship is not particularly strong and can only be described as low to moderate (Connolly & Sluckin, 1958).

Discussion and conclusions

The Mathematics for Initial Teacher Education Students (MITES) project is being conducted in response to concerns about incoming levels of self-efficacy and achievement in mathematics of first year teacher education students at a Queensland university. The purpose of this paper has been to report the background and design of the first stage

of the study, the development of the instruments to test self-efficacy levels in mathematics and the results of the initial tests.

Five self-efficacy and five corresponding achievement tests in mathematics were constructed to determine the pre-test levels of the students on these variables. The self-efficacy scales yielded very high reliability levels, while the achievement scale reliabilities ranged between .50 and .80. It was noted that, while the leastwell performing achievement scales were only as reliable as many informal classroom tests, a further analysis could determine whether increasing the length of these scales would be beneficial. Given that the participants in the study were adult learners, the gains made by lengthening the tests would be unlikely to be eroded by fatigue. It would also be desirable to check the wording of the items contributing least positively to the corrected itemtotal correlations to determine whether there were any anomalies in the ways that these questions were phrased.

The MANOVAs conducted to test for differences on performances on the dependent variables across the four campuses and between males and females with all campuses combined, found a significant difference between means of the students on two campuses on only one achievement scale (fractions). There were no significant differences on any of the dependent variables according to gender.

It has been observed that "the relationship between gender and math self-efficacy has not been explored as thoroughly as that between gender and math performance" (Pajares & Miller, 1994, p. 196). These researchers also note the trends in the results of studies in the area have indicated that girls have caught up to boys in the amount of confidence that they have in their mathematics skills in the elementary school years. Also noted is that males still appear to retain the lead in high school. This finding is also supported in other studies (for example, Randhawa, Beamer & Lundberg, 1993). At first, it may appear that the results of the present study do not follow this pattern but it must be remembered that self-efficacy in relation to mathematics in the MITES project, although being investigated with adults, relates to primary school mathematics. The present study also follows on from the suggestions of Pajares and Miller (1994) and Williams (1994) that more effort needs to be directed to exploring interventions which may lead to higher levels of self-efficacy. This aspect of the study is not reported here but it can be concluded from the results to date that the groundwork in test construction has been completed and will provide the foundation for similar comparisons across cohorts and gender in future stages of the study. Thus the work discussed here, although preliminary, is a necessary step towards the aim of investigating ways of increasing levels of self-efficacy and achievement in mathematics among teacher education students.

References

Bandura, A. A. (1986). Social foundations of thought and action: A social cognitive theory. New Jersey: Englewood Cliffs, Prentice-Hall.
Connolly, T. G. & Sluckin, W. (1958). An introduction fo statistics for the social sciences (2nd edition). London: Cleaver-Hume.
Johnson, D. W., Maruyama, G., Johnson, R., Nelson, D., & Skon, L. (1981). Effects of cooperative, competitive, and individualistic goal structures on achievement: A meta-analysis. Psychological Bulletin, 89(1), 47-62.

Moriarty, B. J., Douglas, G. A., Punch, K. F. & Hattie, J. A. (1995). The importance of self-efficacy as a mediating variable between learning environments andachievement. British Journal of Educational Psychology, 65, 73-84.
Pajares, F. & Miller, M. D. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. Journal of Educational Psychology, 86(2), 193-203.
Randhawa, B. S., Beamer, J. E. & Lundberg, I. (1993). Role of mathematics self-efficacy in the structural model of mathematics achievement. Journal of Educational Psychology, 85(1), 41-48.
Williams, J. E. (1994). Gender differences in high school students' efficacy-expectation/performance discrepancies across four subject matter domains. Psychology in School, 31, 232-237.

Table A1: Reliability analyses for the self-efficacy scales

TermsItem	Corrected Item-Alpha if ScaleTotalitem Correlationdeleted
1.47.89	
2.55.88	
3.76.85	
4.78.85	
5.79.85	
6.79.85	
7.53.88	
Alpha = .88	
Whole numbers1.83.83	
2.83.83	
3.82.83	
4.50.91	
5.65.87	
Alpha = .88	
Measurement1.83.97	
2.71.97	
3.86.97	
4.91.97	

5.92.97
6.93.97
7.93.97
8.93.97
9.85.97
10.78.97
11.79.97
Alpha = .97

Fractions1.88.92
2.88.92
3.86.92
4.82.94
Alpha = .94

Space1.96.94
2.95.95
3.90.96
4.86.97
Alpha = .97

Table A2: Reliability analyses for the achievement scales

Corrected
Item-Alpha if
ScaleTotalitem
TermsItem Correlationdeleted
1.03.53
2.18.49
3.41.36
4.35.40
5.25.46
6.26.46
Alpha = .50

Whole numbers1.40.63
2.12.67
3.33.63
4.56.58
5.28.65
6.19.66
7.32.64
8.42.61
9.36.63
10.40.63
Alpha = .66

Measurement1.23.74

2.30.73
3.44.71
4.40.72
5.41.72
6-.09.75
7.41.72
8.38.72
9.46.71
10.44.72
11.35.72
12.32.73
13.30.73
14.20.74
15.39.72
Alpha = .74

Fractions1.41.79
2.33.80
3.21.80
4.34.80
5.36.80
6.12.81
7.37.79
8.37.79
9.35.79
10.41.79
11.24.80
12.36.79
13.29.80
14.39.79
15.39.79
16.38.79
17.38.79
18.34.79
19.48.79

20.36.79
21.43.79
22.46.79
Alpha = .80

Space 1.25.57
2.42.47
3.38.49
4.31.53
5.32.53
Alpha = .58

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Over several years, concern about the difficulty that first year teacher education students had with basic mathematical concepts developed among staff at a university in Queensland. The problems that students had with understanding and applying very basic concepts as well as what appeared to be equally poor levels of self-efficacy associated with mathematics, were not confined to small groups of students or to isolated years. The problems were ongoing from year to year and involved a high proportion of students. Clearly, two questions emerged: What was the extent of the problem; and What could be done about it? In order to answer these questions and to develop and monitor strategies to overcome these problems, the a study consisting of various stages needed to be planned. The first stage involved determining the extent of the problems that students were experiencing. At the same time, reliable tests needed to be developed in order that the initial assessments could be made.

Self-efficacy: The link between the learning environment and achievement

In recent years, research into co-operative learning and achievement has been establishing the nature and extent of the proposition that the link between the learning environment and achievement is not direct, but is mediated by self-efficacy (Moriarty, Douglas, Hattie & Punch, 1995). Prior analysis of the research comparing the relative merits of different learning environments has established the superiority of co-operative learning environments compared to other learning environments provided that a number of conditions are met. These conditions are that

According to Bandura's (1986) theory, self-efficacy is raised by

success and lowered by recurrent failure. Students, therefore, need to experience success regularly, as they would in a co-operative learning environment in which all group members achieve their goal at the same time and receive rewards according to the quality of the group product. In competitive learning environments, a small number of students experience success at the expense of other students who are unsuccessful and who compare their performances unfavourably with those of the more able students. Learning environments are important, therefore, not only because they may promote success differentially, but also because students may evaluate their abilities inconsistently from one environment to the next.

Clearly, situational variables are important because they provide the qualifications that are necessary in order to predict under what type of specific conditions co-operative environments will promote high self-efficacy and success for all students. The history of research into learning environments indicates that there are six conditions necessary for successful co-operative learning. These conditions concern the estabishment of heterogeneous groups, group goals, high task-means interdependence, individual accountability, student interaction and group rewards.

Research into learning environments has consistently favoured co-operative learning for its positive effects on social connectedness, greater contentment and motivation among students and the pleasure and satisfaction that students derive from actively participating in their learning.

From an examination of the literature relating to the debate following the Johnson et al. (1981) meta-analysis, Moriarty (1991b) proposed that the variability in the results in these earlier studies related to disparities in definitions of co-operative learning as applied across studies. In other words, when studies which produced different results in relation to co-operative learning and achievement were examined, it was found that certain elements needed to be present in order for co-operative learning to be any more effective than the environments with which it was compared. A further proposal tested and found to have substance, is that the link between the learning environment and achievement is indirect and that self-efficacy mediates the two, thus affecting achievement (Moriarty, 1991b, Moriarty, Douglas, Punch & Hattie, 1995).

Even so, the benefits of co-operative learning have been verified through numerous studies and have come into more general acceptance. For example, students have a greater opportunity to have difficult work re-explained when they participate in co-operative group activities (Freeman & Freeman, 1991) because they are encouraged to help each other understand the work. This type of purposeful activity has been associated with a higher degree of task-related interaction among students (Johnson, Johnson & Stanne, 1986), possibly accounting at least in part for the greater motivation that Slavin identified among students who worked co-operatively. Teachers have also maintained that

students cover more material and learn more in-depth under co-operation (Moriarty, 1993). From a slightly different perspective, Tobin and Fraser (1989) found that one of the main characteristics of above-average teachers was that they encouraged their students to become actively involved in the learning process.

Slavin maintained that future research should be conducted in classrooms, that reinforcement should be based at the small-group level and the treatment period should be extended to at least 4 weeks. It is surprising how few classroom studies have been conducted over a longer period, an exception being the study into self-efficacy and learning environments by Moriarty (1991b), which was implemented over a 10-week period and which also satisfied Slavin's other two criteria.

In later articles following their meta-analysis, Johnson and Johnson (1982, 1985) recommended that students should be taught to work in a variety of learning environments. Teachers should, for example, aim to include co-operative methods in their classrooms rather than continue to use competition and individualisation without discretion. This approach would allow teachers to provide for the different learning styles of their students. One of the problems that Johnson and Johnson (1982) identified, however, was that teachers did not really know how to structure co-operative learning environments. Teachers needed to be aware of a range of issues, including the specification of objectives and the provision of appropriate materials. Johnson and Johnson (1982) also emphasised the importance of observing student behaviour to ensure that students co-operated among themselves when the goal structure was intended to be co-operative and to intervene when students displayed unco-operative behaviours in these situations. In this article, the Johnsons also reaffirmed their position in favour of co-operative learning environments for achievement (in terms of mastery, recall, transfer of concepts, rules and principles), motivation, cognitive and social development, attitudes, self-esteem and psychological health.

Cotton and Cook (1982) agreed with Johnson et al. (1981) that many classroom situations would be better constructed co-operatively, especially when interpersonal relations were a concern. Cotton and Cook placed a greater emphasis, however, on the interaction between reward systems and situational variables. The variables which they maintained should receive more prominent attention were task interdependence (how the different tasks that group members complete contribute to the group goal), type of task, group size and the provision or absence of opportunities for group members to have contact with one another. Cotton and Cook also reported the Johnson finding that a large part of the variance in results between co-operative and competitive learning environments remained unaccounted for, over and above the situational variables already mentioned. As stated earlier, self-efficacy has more recently been proposed as the most important additional mediating variable.

The differences between the arguments presented for and against co-operative learning in terms of achievement can be reconciled through

what appear to be the two most important sources of common concern. One is the definition of the learning environments under question, particularly in relation to task interdependence, the presence or absence of the opportunity for group members to share resources and the individual accountability of each of the members. The other is the recognition that there may exist between the environmental structure and level of achievement, intervening variables which have yet to be acknowledged and examined in that context. Even so, the proponents of co-operative learning maintain that the benefits of this environment can be made available to all students, including the gifted and the less academically able. Studies which have concluded that gifted or below average students do not gain under co-operative learning (for example, as reported by Crawford, 1993) need to be examined in the light of whether they define co-operation to include what are now regarded as elements essential for the successful implementation of co-operation learning. These elements are discussed in the final section of this article.

Methodological overview

Substantive overview

Johnson and Johnson (1987, 1991) list individual accountability as an important element for effective co-operative work. Slavin (1987a, 1987b, 1988, 1989) has also continued to maintain that individual accountability, having a group goal and student interaction are essential for achievement gains under co-operation. Interestingly, the issue of accountability seems to be one of the main concerns of teachers who have some information on co-operative learning but who lack detailed knowledge and training.

In many of the studies in which co-operative environments were found to be less effective, the participants were completing identical tasks and the group product was simply a combination of their individual results. In these situations, none of the participants contributed anything which was different from that which the other participants contributed. The alternative is to have each member of a group complete a different task, the achievement of which is a necessary requisite for the attainment of the group goal. Incorporating high task means-interdependence in this way places a greater responsibility on the individual members of the group. It is likely to increase the perceived value of each member's participation, provided that the number of students in each group is not too large, thus ensuring that each person's contribution to the group goal is substantial. Generally, no more than six students per group is most ideal.

In the co-operative learning environments small, heterogeneous groups of students work towards common group goals. Allocation to groups should be based on ability and other student characteristics such as gender and race or ethnicity, so that the small groups are truly heterogenous and reflect as far as possible the characteristics of the entire class. In this way, harmony among heterogenous groups of

students will result from their helping one another and valuing each other's contribution to the group goal. The heterogeneity of the groups, especially in relation to ability is very important. It is the reason why studies which compare the achievement of homogeneous groups across environments are unlikely to favour co-operation.

Method

The study is being implemented across four campuses of a regional university in Queensland and has involved most of the first year 1995 Bachelor of Education students in the Faculty of Education. One hundred and fifty-nine students who agreed to participate in the study were given pre-tests of self-efficacy and achievement in mathematics at the commencement of the academic year. These tests were based on the year 7 mathematics syllabus with questions on the self-efficacy scales paralleling those on the achievement scales. The self-efficacy and achievement scales sampled the areas of Terms, Whole numbers, Measurement, Fractions and Space. The self-efficacy scales were administered immediately prior to the achievement scales so that self-efficacy levels would not be related to the perceived difficulty of the achievement scales. Table 1 is a summary distribution of students tested across campuses.

The students were permitted up to one hour to complete all the pre-tests, although most were able to finish well within this time.

Construction and psychometric characteristics of the pre-tests

The self-efficacy scales were based on a 6-point response format and directly related to the concepts tested in the achievement scales. Table 2 shows the corresponding verbal descriptions with each numerical value on the scales,

The six-point response format was chosen because it was small enough for each response to have a meaningful descriptor, both on its own and in relation to the other descriptors and large enough to encourage discrimination. An even number of choices was less likely to promote more thought before responding and more likely to discourage a possible tendency to check the middle of the scale. This type of approach has been used before on similar self-efficacy scales (Moriarty, Douglas,

Hattie & Punch, 1995). Each question was marked on a scale from 1 to 6. There were five self-efficacy scales. The number of items per scale are listed in Table 3.

The first pre-test scale on self-efficacy (Terms) is reproduced below, showing how the scale was presented to the students.

Central Queensland University
Faculty of Education
Mathematics for Initial Teacher Education Students (MITES)

Name: (for collating results only).
Campus:
1.
In your maths classes when you were in primary school you worked with a number of mathematical concepts. Please indicate below how confident you feel with your current understanding of each of the following concepts. *

	1	2	3	4	5	6
composite angle						
multiple						
obtuse angle						
isoseles triangle						
parrallelogram						
perpendicular						
hectare						

2.
How confident do you feel with your current working knowlege of whole numbers, such as when dealing with: *

	1	2	3	4	5	6
subtraction						
multiplication						
addition						
expanding numbers						
factors						

*1 = Not very confident at all
2 = Only just confident
3 = Reasonable confident
4 = Very confident
5 = Extra confident
6 = Super confident

The response descriptors were provided at the bottom of each page.

The pre-test of mathematics achievement also contained five scales, corresponding to the scales in the test of self-efficacy. Table 4 is a summary of the number of items per scale for achievement.

Each item was marked 1 if correct and 0 if incorrect.

Results of the pre-tests

Descriptive statistics

The descriptive statistics for the pre-test scales of self-efficacy are shown on Table 5. The responses for each sub-scale, while ranging from not very confident at all to super confident, tended to cluster more around the middle.

The descriptive statistics for the corresponding pre-test scales of achievement shown on Table 6, indicate the mean score on each sub-scale.

The results on Tables 5 and 6 relate to the scores of all students across all campuses.

In order to determine the efficacy of each scale and how well the items and scales worked, reliability analyses were carried out. The results, shown on Table 7, indicate that the scales, particularly self-efficacy, worked well overall, with most items contributing.

A examination of the information on Table 7 indicates that the reliability of each self-efficacy scale was higher than the reliability of the corresponding scale for achievement. While all self-efficacy scales performed well, two of the scales measuring achievement (Terms and Space) produced reliabilities only commensurate with most classroom tests. It would be expected, however, that the self-efficacy scales would yield higher reliabilities, this is typical of attitudinal scales. Even so, the levels were very good.

Tables A1 and A2 in the appendix show the corrected item-total correlations for each item on each scale of self-efficacy and achievement, as well as the alpha levels of the scales if any particular items were omitted. The self-efficacy scales have only a few isolated items with relatively low corrected item-total correlations but these items need not be omitted because the overall reliabilities are still high and omiting any particular item would not make very much difference. The resulting overall reliability for each achievement scale would also not alter much if any less-well performing items were omitted.

Two other possibilities could be investigated in relation to the reliabilities on the achievement scales. One is that the items could be

examined at face value to determine the existence of any obvious reasons why those items might perform relatively poorly. The wording of the items, for example, may need to be improved. Secondly, the Spearman-Brown formula could be applied to those achievement scales with low reliabilities to calculate whether using twice or three times the number of items with similar levels of difficulty to those already included, would raise the reliabilities. Using scales with more items would be acceptable because it would be most unlikely to lead to fatigue among adult students which, if present, could counter the effects of the longer scales.

The results of the pre-tests are considered in the next section of this paper. ANOVAs to test for differences between the performances of the students on the different campuses and between male and female students overall on each of the scales of self-efficacy and achievement were conducted. Prior to this, UnivariateTests for Homogeneity of Dispersion Matrices were implemented in order to determine whether it was appropriate to proceed with the ANOVAs. Finally, the correlations between performances on the self-efficacy scales and the corresponding

achievement scales were calculated.

Results

Univariate Homogeneity of Variance Tests were conducted for each self-efficacy and achievement scale. The results showed the need for very little concern, with each test producing an approximate pvalue >0.05 on either Cochran's or the Bartlett-Box or both, except for the achievement test on fractions, in which both tests reported a vvalue below 0.05.

It was, therefore, considered appropriate to proceed with the ANOVAs, first testing for differences between campuses and secondly, differences between males and females across all campuses combined. Table 8 shows that the ANOVA

Table 9 shows that the MANOVA for the pretests produced a Wilks Lambda of .93, converting to an F of .93 and a pvalue of .51. This result indicated that there were no significant differences between males and females on any of the dependent variables. Accordingly, an examination of the univariate F-tests also indicated no significant differences across sexes.

Table A1: Reliability analyses for the self-efficacy scales.

Item-Terms	Corrected ScaleTotal Correlation	Alpha if item deleted
1.47.89		

2.55.88
3.76.85
4.78.85
5.79.85
6.79.85
7.53.88
Alpha = .88

Whole numbers1.83.83
2.83.83
3.82.83
4.50.91
5.65.87
Alpha = .88

Measurement1.83.97
2.71.97
3.86.97
4.91.97
5.92.97
6.93.97
7.93.97
8.93.97
9.85.97
10.78.97
11.79.97
Alpha = .97

Fractions1.88.92
2.88.92
3.86.92
4.82.94

Alpha = .94

Space1.96.94
2.95.95
3.90.96
4.86.97
Alpha = .97

Table A2: Reliability analyses for the achievement scales.

Corrected
Item-Alpha if
ScaleTotalitem

TermsItemCorrelationdeleted

1.03.53
2.18.49
3.41.36
4.35.40
5.25.46
6.26.46
Alpha = .50

Whole numbers1.40.63
2.12.67
3.33.63
4.56.58
5.28.65
6.19.66
7.32.64
8.42.61
9.36.63
10.40.63
Alpha = .66

Measurement1.23.74
2.30.73
3.44.71
4.40.72
5.41.72
6-.09.75
7.41.72
8.38.72
9.46.71
10.44.72
11.35.72
12.32.73
13.30.73
14.20.74
15.39.72
Alpha = .74

Fractions1.41.79
2.33.80
3.21.80
4.34.80
5.36.80
6.12.81
7.37.79

8.37.79
9.35.79

10.41.79
11.24.80
12.36.79
13.29.80
14.39.79
15.39.79
16.38.79
17.38.79
18.34.79
19.48.79
20.36.79
21.43.79
22.46.79
Alpha = .80

Space1.25.57
2.42.47
3.38.49
4.31.53
5.32.53
Alpha = .58

Table 1: Summary of distribution of participants across campuses.

CampusNumber
A90(R)
B11(M)
C32(B)
D26(G)
Total159

MalesFemales
18118

Central Queensland University
Faculty of Education
Mathematics for Initial Teacher Education Students (MITES)

Name: (for collating results only).
Campus:
1.
In your maths classes when you were in primary school you worked with a number of mathematical concepts. Please indicate below how confident you feel with your current understanding of each of the following concepts. *

1 2 3 4 5 6

composite angle
multiple
obtuse angle
isoseles triangle
parrallelogram
perpendicular
hectare

2.

How confident do you feel with your current working knowlege of whole numbers, such as when dealing with: *

1 2 3 4 5 6

subtraction
multiplication
addition
expanding numbers
factors

*1 = Not very confident at all
2 = Only just confident
3 = Reasonable confident
4 = Very confident
5 = Extra confident
6 = Super confident

Central Queensland University
Faculty of Education
Mathematics for Initial Teacher Education Students (MITES)

Name: (for collating results only).
Campus:
1.
In your maths classes when you were in primary school you worked with a number of mathematical concepts. Please indicate below how confident you feel with your current understanding of each of the following concepts. *

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parrallelogram

perpendicular
hectare

2.
How confident do you feel with your current working knowlege of whole numbers, such as when dealing with: *

1 2 3 4 5 6

subtraction
multiplication
addition
expanding numbers
factors

*1 = Not very confident at all
2 = Only just confident
3 = Reasonable confident
4 = Very confident
5 = Extra confident
6 = Super confident

Self-efficacy

1.
In your maths classes when you were in primary school you worked with a number of mathematical concepts. Please indicate below how confident you feel with your current understanding of each of the following concepts. *

1 2 3 4 5 6
composite angle
multiple
obtuse angle
isoseles triangle
parrallelogram
perpendicular
hectare

*1 = Not very confident at all

2 = Only just confident
3 = Reasonable confident
4 = Very confident
5 = Extra confident
6 = Super confident

The response descriptors were provided at the bottom of each page.

The pre-test of mathematics achievement also contained five scales, corresponding to the scales in the test of self-efficacy. Table 4 is a summary of the number of items per scale for achievement.

Table 4: Achievement scales administered as pre-tests

ScalesNumber of items
Terms6
Whole numbers10
Measurement15
Fractions 20
Space5

Table 1: Summary of distribution of participants across campuses.

CampusNumber
A90(R)
B11(M)
C32(B)
D26(G)
Total159

MalesFemales
18118

Table 10: Correlation co-efficients

Achievement
Self-efficacyTermsWholeMeasureFractionsSpace

Terms.39

Whole .48

Measure.48

Fractions.37

Space.25

Table A2: Reliability analyses for the achievement scales
ScaleItemCorrected Item-Total Correlation Alpha if item deletedScale
ItemCorrected Item-Total Correlation Alpha if item deleted

Terms (Alpha = .50)1.03.53
2.18.49
3.41.36
4.35.40
5.25.46
6.26.46
Whole numbers (Alpha = .66)1.40.63
2.12.67
3.33.63
4.56.58
5.28.65
6.19.66
7.32.64
8.42.61
9.36.63
10.40.63
Measurement (Alpha = .74)1.23.74
2.30.73
3.44.71
4.40.72
5.41.72
6-.09.75
7.41.72
8.38.72
9.46.71
10.44.72
11.35.72
12.32.73
13.30.73
14.20.74
15.39.72
Fractions (Alpha = .80)1.41.79
2.33.80
3.21.80

4.34.80
5.36.80

6.12.81
7.37.79
8.37.79
9.35.79
10.41.79
11.24.80
12.36.79
13.29.80
14.39.79
15.39.79
16.38.79
17.38.79
18.34.79
19.48.79
20.36.79
21.43.79
22.46.79
Space (Alpha = .58)1.25.57
2.42.47
3.38.49
4.31.53
5.32.53

Table A2: Reliability analyses for the achievement scales

Corrected
Item-Alpha if
ScaleTotalitem
TermsItemCorrelationdeleted
1.03.53
2.18.49
3.41.36
4.35.40
5.25.46
6.26.46
Alpha = .50

Whole numbers1.40.63
2.12.67
3.33.63
4.56.58
5.28.65
6.19.66
7.32.64
8.42.61

9.36.63
10.40.63
Alpha = .66

Measurement1.23.74
2.30.73
3.44.71
4.40.72
5.41.72
6-.09.75
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8.38.72
9.46.71
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13.30.73
14.20.74
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Alpha = .74

Fractions1.41.79
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3.21.80
4.34.80
5.36.80
6.12.81
7.37.79
8.37.79
9.35.79
10.41.79
11.24.80
12.36.79
13.29.80
14.39.79
15.39.79
16.38.79
17.38.79
18.34.79
19.48.79
20.36.79
21.43.79
22.46.79
Alpha = .80

Space 1.25.57
2.42.47
3.38.49

4.31.53
5.32.53
Alpha = .58