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ABSTRACT

The comparative effects of large and traditional-sized remedial mathematics classes on college student aptitude and attitude were studied. Two large pre-algebra classes of 129 and 121 students and traditional-sized classes ranging in size from 30 to 40 students were assessed by informal observations and two instruments: a department-developed placement tool and an attitude measure developed by Grayson Wheatley. Additionally, post-test information concerning student characteristics, educational background, and other data were obtained. For both the 135 students in the large classes and the 85 students in the traditional-sized classes, there was a positive change in aptitude, which was significant at the .05 level. For the students in the large classes, there was a significant negative change in attitude. Although some negative change in attitude occurred for students in the traditional-sized classes, there was a significant difference in negativity between the two study groups. Factors in addition to size that may have contributed to the more negative attitudes of students in the large classes include the instructional facilities, not having laboratory experiences as part of the regular class, and being assigned to a large class because of a situation that arose at the department. Additionally, there were more upper level students in the large classes than in the small classes. Additional information obtained after class completion and aptitude/attitude testing are considered as follows: student grade expectation, reasons for taking the course, study habits, preference for multiple choice versus scantron testing, perceived clarity of course objective, class attendance, and withdrawal. (SW)

Effects of Class Size Upon Aptitude and Attitude of Pre-Algebra Undergraduate Students

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Introduction

"John, Bill decided not to accept the instructorship we offered. How about combining a couple of his classes with yours? They meet at the same time. We'll arrange for a class reduction in the Spring." "John, the budget is tight and there's no way, except by doubling up, to meet the Fall schedule. Would you mind taking a combination of three classes to help shoulder the load? We'll trade off in the Spring with a reduced teaching load." "John, you've been wanting some time to pursue other interests. How about teaching a couple of extra large classes instead of three regular classes?" "John, during registration the course demand was incredible. In order to try to meet the demand we opened up a couple of large sections. We need someone desperately to teach them. How about a two for three trade?" These and other excuses similar to these have been used in the process of deviating from traditional class sizes.

On the other hand, rarely does one hear, "John, we want to start offering large classes since it is well established that students are more successful." "John, we would like to offer a couple of extra large classes on an experimental basis. We would like to know how this may influence student learning. Also, we're interested in how this may influences basic teacher concerns."

Too often important educational decisions are based upon gut level feelings of the persons involved and seldom is there much of an effort to gather unbiased evidence relative

to these decisions. Basically decisions to deviate from traditional class sizes have been more a function of administrative concerns or faculty convenience, rather than based upon quality educational considerations. A review of the literature and the apparent scarity of available research on this issue may further indicate a certain reluctance to investigate these concerns.

General Purpose

The purpose of this study was to investigate the difference, if any, in student aptitude and attitude that may be a result of deviating from traditional class size in remedial mathematics classes.

Background

This university, similar to many of the state universities, has virtually an open door policy for admitting students. The majority of students admitted have merely met minimal state mathematics requirements and are unable to successfully complete college algebra. Consequently, the Mathematics Department offers a remedial course in topics and skills which are prerequisite to ideas and skills of algebra. The course is basically geared to bridge the gap between a poor mathematics preparation and success in college algebra or technical courses.

For many years the department has been able to resist the temptation to expand class sizes. Class sizes, until recently, at the freshman level, have average about thirty students. Facil-

ities were constructed with capacity of forty students per class. Each class is equipped with maximum blackboard space available on each of the walls. Because of recent budget urgency and sometimes inflated course demands the average class size has increased to classroom capacity.

Typical instruction in the remedial mathematics class, under ordinary circumstances, consists of a few minutes of lecture. The bulk of the class time is spent in closely supervised student work on problems at the blackboards. Assignments are usually discussed in class and student homework is graded in detail by the instructor or student graders. Exams are generally responded to by students recording details of solutions and these solutions are graded in detail by the instructor. Instructors are generally half-time graduate students.

Most recently, for reasons similar to the introductory statements, the department decided to offer two large classes of remedial mathematics.

Experimental Classes

One of the large classes was formed during registration in an effort by the department to meet student demand for a class. although the course is remedial, the course is required, directly or indirectly, in a substantial number of degree programs. Typically, a sizeable crowd of students waits until the junior or senior level before trying to satisfy the mathematics requirements. The department senses a responsiblilty to try and provide students with a class, particularly for those students whose degree program

is at a critical stage. With sufficient student demand, the department succumbed, after offered classes were filled, by opening an additional class. This class was announced to be open ended on size. After the add/drop period the class ended up with 129 students.

The other class formed after the fact. That is, there was an anticipated instructor who didn't materialize. Yet the department was obligated to the scheduled classes. Consequently three classes that were scheduled at the same time were combined to form a class. These students were not aware that they had registered for a large class. Class size was 121 students.

In neither case was the decision based upon substantial evidence the the students would receive essentially the same educational benefits. Nor were the classes formed on an experimental basis, This was an individual concern after the decisions had been executed.

Some Instructional Differences

The department was caught without adequate facilities for teaching large classes. After a couple of moves the instructor located somewhat minimal facilities for holding class; at least students could see and hear the instructor. A portable blackboard, overhead projector and screen were available for supplementing lectures and discussions of assigned problems with demonstrations of examples by the instructor. Objective/mutiple choice assignments and exams were oriented to and monitored by scantron equipment. The book, sequence of topics and problems were the same as used in the traditional classes. However, since there was extremely limited blackboard space available, there was no supervised board-

work on problems during class periods. Tutorial/help sessions at surveyed convenient times were scheduled. Also, office hours were doubled. Tutorial/help sessions and expanded office hours were handled by a student aide. Attendance at tutorial help sessions or office visits was strictly voluntary on the part of the enrolled students. There was very infrequent attendence or participation in either situation, about on par or less than interaction with students during office hours, ordinarily. Student interaction, as a group, during class meetings was also on par or less than ordinary with a very few students carrying the load of reacting to leading questions, lecture comments, or demonstrated examples. Assignments were generally selectively sampled during the first few minutes of each class period and the results returned at the end of the period. The majority of each instructional period involved a discussion of selected assigned problems, lecture over current topics supplemented by demonstrated examples with encouraged student interaction. Differences, as mentioned above, while perhaps not a direct result of class size, were influenced by the change in class size.

Forming the Study

The two classes were perceived by the instructor as an experimental group. Four classes of traditional size were chosen to serve as sources of control data. The selection of these classes was not random, however. Classes were chosen to have similar factors such as time of day and duration of class meeting. Also the control classes were chosen to include a variety of instructors, including the only instructor with some previous university teaching

experience. The instructors of the remedial mathematics courses are generally closely supervised part-time graduate students. Two of the three control group instructors fall into this category. One of these instructors was certified to teach at the secondary level and had previous secondary experience. Another of the instructors had five previous years of university teaching experience as a doctoral student at another institution. None of this previous experience was with a course similar in scope to the course under consideration. The instructor of the experimental group was certified with five years of secondary experience and fifteen years of university experience, including the teaching of courses similar in scope to the remedial course. As much as possible, under the circumstances, the study attempted to negate schedule differences and instructor differences.

Instruments Used in the Study

Besides informal observations of the instructor of the experimental group during the semester, two instruments were developed and applied to help determine what differences, if any, occurred with respect to student aptitude and attitude.

The department, during the last decade, had developed a placement tool to help students decide upon appropriate mathematics coursework. Problems from this placement exam comprise the aptitude measuring tool for this study. An ttitude instrument, developed and field tested by Grayson Wheatley, Professor of Mathematics and Education at Purdue University, was used as an attitude measuring device for this study.

A pretest composed of the aptitude and attitude instruments was administered during a class period of the first week of class meetings. Time to administer these tools was less than a class period in every case.

For informational purposes on factors which may relate to the study, an additional set of items was developed for the post test. The post test was composed of the same aptitude and attitude tools with the additional information items. This was administered to those students who were still enrolled and in attendance during a class meeting of the last week of the semester. Again, administration time was less than a class period.

Since students were identified on both the pretest and post test records, the scores were paired and records for which there were no pairings (enrolled late, absent, withdrew from class, failure to identify) were discarded. There were 86 paired student records in the Control Group and on 135 paired student records in the Experimental Group.

Results of Main Factor Measures

Students in both groups changed in aptitude, positively and significantly, at the .05 level, Table 1. Also, as indicated in Table 1, there was no significant difference in aptitude at the beginning or end of the semester or in the change in aptitude between groups.

	Control Group (n=86)		Experimental Group (n=135)		Between Group
	Mean	Standard Deviation	Mean	Standard Deviation	
Pretest	9.3605	3.0828	8.9481	3.3375	z = 0.9385
Post test	12.6860	3.6080	12.2148	4.2186	z = 0.8855
Change	3.3256	3.7806	3.2667	3.9022	z = 0.1115
Within Group	z = 6.4984		z = 7.0560		

Table 1 Aptitude Measures of Central Tendency and Comparisons.

Students of the Control Group changed in attitude, Table 2. negatively, but not significantly. Students in Experimental Group changed significantly in attitude, Table 2, negatively, at the .05 level, however. There was no significant difference in measured attitude on the pretest. But, there is a significant difference negatively on the post test. Also, as is recorded in Table 2, there is a significant difference in the change of attitude between the groups. The Experimental Group changed in attitude, negatively and significantly more so than the Control Group, at the .05 level.

	Control Goup (n=86)		Experimental Group (n=135)		Between Group
	Mean	Standard Deviation	Mean	Standard Deviation	
Pretest	55.5814	16.4663	53.5704	13.6576	z = 0.9444
Post test	55.5465	17.5979	48.5407	16.3884	z = 2.9630
Change	-0.0349	12.1029	-5.0296	11.3624	z = 3.0627
Within Group	z = -0.0134		z = -2.7394		

Table 2. Attitude Measures of Central Tendency and Comparisons.

Informational Measures

Informational items sought to determine factors, if any, which may have biased the results of the study. These items are in Table 3.

Non significant factors, outlined in Table 3, included sex, age, GPA estimate, class level, number of previous attempts with the course, high school mathematics course, previous university level mathematics, intentions as to taking algebra and when, outside class assistance, estimate of absences, preference for instructional modes.

Factors	Control Group $\bar{C}$	SD	Experimental Group $\bar{X}$	SD	Between Grou z
Sex	1.4070	0.5816	1.3333	0.5985	0.9074
Age	1.4419	0.9153	1.6222	0.9763	-1.3914
GPA	2.7442	1.0196	2.6963	1.0739	0.3334
Class Level	0.9884	0.4199	1.1852	0.7143	-2.5777*
Grade Expectation	2.1860	1.2320	3.9556	7.6049	-2.6495*
Number of Previous Attempts	0.9651	0.2400	1.0519	0.6147	-1.4727
Reason for Taking Course	3.5581	1.6349	3.0963	1.6611	2.0347*
Yrs. of High School Mathematics	2.7326	1.0784	2.6593	1.0938	0.4899
Previous University Math. Courses	1.1512	0.9142	1.2444	1.0822	-0.6878
Using Course for Algebra	2.000	1.1167	2.0667	1.1857	-0.4224
Outside Class Assistance	1.5698	0.8759	1.4370	0.7785	1.1469
Assignment Study Habits	2.4884	0.8911	2.0741	0.8607	3.4148*
Preferred Assignment/Exam Mode	1.4419	0.6251	1.6519	0.6025	-2.4694*
Estimate of Number of Asbsences	2.3256	1.1318	2.1401	0.9476	1.2592
Preferred Class Size	1.3837	0.6356	1.3815	0.7885	1.0600
Preferred Instructional Mode	1.3605	0.6671	1.3037	0.7152	0.5995
Perceived Clarity of Objective	1.6512	0.6466	1.1778	0.6897	5.1699*

Table 3. Informational Factors, Central Tendency Measures and Comparisons.

Absences were recorded in one of the control classes and the Experimental Group, listed in Table 4. The number of absences was not significantly different between the groups.

	Control Class (n=22)		Experimental Group (n=135)		Difference
	Mean	Standard Deviation	Mean	Standard Deviation	
Absences	2.2609	0.9638	2.1704	0.8244	z = 0.4246

Table 4. Measures of Central Tendency and Comparison of Absences Between a Control Class and the Experimental Group.

Factors which tended to indicate the groups were significantly different at the .05 level are listed in Table 3(*) and will be discussed individually.

The significance of Class Level supports how one of the classes was formed. The Experimental Group included more upper level students than the Control Group. This is also somewhat indicated in the Age factor. This difference is a function of how one of the experimental classes was formed during registration, rather than primarily a function of class size. How Class Level affected the aptitude or attitude measures is not clear.

Grade Expectation between the groups was significantly biased. A possible explanation might be that upper level students expect better grades, but that is not what is indicated in the measures of central tendency. The Control Group expected to earn a grade close to a B. The Experimental Group expected about a D. This may indicate a certain lack of confidence in ability and may be reflected in the latency of taking the course by students of the Experimental Group. On the other hand, grade expectancy may be a function of the reputation (or lack of reputation) of the instructor. The

rumor mill indicates that graduate assistants have a tendency for higher grades. In fairness, the same rumor mill indicates that the instructor of the Experimental Group has a reasonable stiff reputation with respect to grades. Although there is no specific evidence presented here which demonstrates how grade expectation affects aptitude or attitude, there does seem to be a positive correlation between grades and attitude, i.e. low grades may be associated with low attitude scores.

The significance of Reasons for Taking the Course may be better understood by looking at the available responses for this informational factor. The first response, associated with a score of one, merely indicated that the individual had been advised to take the course after initially enrolling in algebra, a part of the placement program. The second response, associated with a score of two, indicated that the course was perceived as academic foundations requirement. The third response indicated that the course was a required course within the students' major. The fourth response, four, indicated the course was considered an elective. The fifth part, five, indicated the course was being taken because of a poor mathematics background. These responses do not seem to be mutually exclusive and the measures of central tendency and the resultant comparison is probably not very meaningful. A better presentation of this information in terms of percentage is presented the Table 5. None the less, it is difficult to understand how the indicated bias may have influenced aptitude or attitude.

	Control Group						Experimental Group					
Response	1	2	3	4	5	0	1	2	3	4	5	0
% of Group	5	13	16	14	44	8	8	23	19	5	35	9

Table 5. Percentage of Groups Responding to Items of the Reasons for Taking the Course.

The bimodal distribution of students of the Experimental Group, as indicated in Table 5, may be accounted for by the way one of the experimental classes was formed during registration since upper level students are more likely to be concerned and conscious of the academic foundation aspects of taking the course.

The measures of central tendency of Assignment Study Habits as stated in Table 3 do not give many clues about this bias. Table 6 indicates that the bias may be attributable to the second experimental class. The second experimental class was the class formed during registration to meet student demand for a class. There may be a relationship between Assignment Study Habits and aptitude or attitude. If so, one would suspect a positive relationship, that is, increased involvement of students with assignments should be reflected with higher aptitude or attitude scores. Notice that is indeed the case with respect to aptitude but does not seem to be the case with respect to attitude. On the other hand notice that there does seem to be a relationship with attitude. Although attitude is negative, though not significantly so with the Control Group, the attitude is lower for the Experimental Group as is the level of involvement with respect to assignments.

Assignment Study Habits	Control Group				Experimental Group First Class				Experimental Group Second Class			
Response	0	1	2	3	0	1	2	3	0	1	2	3
Frequency	6	4	15	61	8	18	61	48	4	6	38	24

Table 6. Frequency of Responses on Assignment Study Habits for Each Group.

As indicated in Table 7 students of both groups seem to prefer the objective (scantron/multiple choice) mode over the standard written mode for assignments and exams. Students in general seem to express little resistance to the multiple choice format on mathematics instruments. Since the Control Group used the traditional written work mode for assignments and exams and have long been associated with this mode, it is not very surprising to notice the relatively even split in responses. On the other hand, the Experimental Group used the multiple choice mode exclusively. Apparently the mode was very agreeable with them, judging from the overwhelming second choice. Perhaps one could make a weak case relating the bias to the main effects of aptitude and attitude. But, it is doubtful that such a relationship would be negative as it appears to be with the attitude measures. Without a natural explanation one suspects that these factors may be reasonably independent.

Assignment/Exam Mode	Control Group			Experimental Group		
Responses	0	1	2	0	1	2
Frequency of Responses	6	36	44	10	29	96

Table 7. Frequency of Responses on Assignment/Exam Mode for Each Group.

The results on Perceived Clarity of Course Objective seem strong. The frequency distribution as listed in Table 8 indicates that students in the Control Group felt that they understood the objectives of the course while students in the Experimental Group were split in responses. A survey of the results of the two experimental classes seems to indicate no difference between the classes. One may be able to make a case for relating aptitude or attitude to perceived clearness of course objectives, and the expected relationship would be positive. The results do not tend to negate such a expectation with respect to attitude. Notice that the Control Group had a more positive attitude and seemed to understand the course objectives better and vice versa for the Experimental Group. On the other hand perceived understanding of course objectives may be subject to interpretation. Every effort was made in the experimental classes to make sure that the course objectives were clearly stated in detail. Obviously this did not come across. It may well be that the opportunity to practice skills under direct supervision and to have written work graded in detail may have a tendency to emphasize some of the specific goals of a course. Watching the instructor work examples and not having the direct supervision at boardwork or critical analysis of written work may not emphasize some of the specific skills enough. This may indicate a need to require problem solving sessions in adequate facilities in addition to lecture sessions. So this bias may be function of the specifics of the present organization and facilities for large group instruction rather than simply class size.

Perceived Clearness of Course Objectives

	Control Group			Experi-mental			First Class			Second Class		
Response	0	1	2	0	1	2	0	1	2	0	1	2
Frequency	9	14	63	22	64	49	10	29	24	12	35	25

Table 8. Frequency of Responses on Perceived Clearness of Course Objectives for Each Group.

Withdrawals from the groups may give some clue as to students attitude and class size interaction. Nineteen students withdrew from the Control Group. Forty students withdrew from the Experimental Group. Twenty five percent of the students withdrawals of the Experimental Group referred to class size as a basis for withdrawing. None of the Control Group withdrawals Complained about class size. Half of the Experimental Group were not aware that they were registered for a large class and the withdrawals indicated a resentment to being in a large class. Again, formation of the Experimental classes may have contributed a bias to the negative attitude results.

Conclusions

Apparently deviation from traditional class size within the limitations imposed by the formation of the experimental classes and the limitations of the facilities did not cause a significant difference in the aptitude of the students as compared with the control classes. With respect to the attitude factor, there is some evidence that the attitude of students in the experimental classes was significantly affected, negatively. There are, however,

factors, which may also have contributed to this negative change in attitude. The formation of the experimental classes, instructional facilities and no assigned laboratory experiences emerge as factors which may have clouded validity of this conclusion. Attitude is generally considered an important aspect of the learning situation. Consequently, one should be aware that the mathematical attitude of remedial students may be negatively modified when deviating in class size (larger).

Seggestions for Further Study

Perhaps an initial suggestion, depending upon the pressures for expanding class size, would be to replicate the study but with better formation of class strategy, involvment of more faculty with experimental classes to help modify instructor differences, in an educational environment more suited to large class instruction, include laboratory experiences and some modifications of the informational diagnostic tool. An interesting spin off may be to further investigate the instructor differences. One certainly may want to try to determine if there may be strategies, perculiar to large groups of students, that may modify their attitude positively. Certainly one should be cautious about deviating from traditional successful formats when teaching students with a background of failure in mathematics who need the skills and ideas for continuing their educational needs.

B I B L I O G R A P H Y

1. Wheatley, Grayson, Instrument for measuring mathematical attitude at the undergraduate level, Permission to use this instrument for the purpose of this study was granted by Grayson Wheatley, Professor, Purdue University.