CHAPTER V

EXPERIMENT

5.1   Introduction

Science, with it permanent place till the end of
the secondary school education in India, requires firm
support from research findings for its dissemination to
all students with varied backgrounds and aspirations.
There is now a growing awareness among the people involved
in science education that some of the basic ideas of
science are difficult for children to understand. This
demands, trying out various alternate teaching strategies
to help the practioners, so that teaching will become
more efficient. Observers of the education scene might argue
that teachers should be willing to be informed by relevant
educational research and modify their teaching strategies
accordingly but many a times the ideas from research findings
are difficult to put into practice, simply because of its
difference with the classroom realities. Any teaching
strategy, therefore, designed and developed, should take
the classroom situation as it is; without tampering with it,
that can only lead to an efficient uptake of research
findings in the classroom situation. The experiment
described here is a step in this direction.

The study, presented here, is intended to examine the potential, that Gagne's conditions of learning, holds for classroom teaching through the utilization of carefully developed learning materials and instructional strategies. The part concerned with the development of instructional material has already been described in the earlier chapter. The present chapter relates to experimental verification of the effectiveness of the instructional strategy, designed according to Gagne's conditions of learning. Thus, the present chapter describes the conduct of an experiment in the actual classroom situation utilizing the instructional materials developed earlier. Details of the experiment in terms of design, sample, treatment, data collection and analysis, are presented in this chapter.

The experiment described here attempt to :

(i) determine the major areas in content, viz., concepts, rule or problem solving, where students show their general weaknesses and which need special attention, based on the criterion test scores performances.

(ii) modify, if necessary, the instructional material prepared as classroom learning material and self learning material based on the feedback from the performance at the criterion tests and discussions with the students.

(iii) find whether the instructional strategy
adopted was more successful in a particular
area of the content, viz., concept, rule
or problem solving.

(iv) examine whether the instructional strategy
has helped the low achievers or high
achievers in particular.

(v) validate the instructional strategy against
the traditional method of instruction.

5.2   Design

The study adopted an experimental-control group
design for the conduct of the experiment. The experimental
group and the control groups were the A and B section of
an existing class. The selection of the section as the
experimental group was done randomly. The students of A
and B sections were not disturbed at all as it was considered
more appropriate to have the experiment performed in the
actual classroom environment within the normal parameters
of a school situation. The redistribution of the students
into two new sections would have also created administrative
problems in the school. Thus, no effort could be done to
match the two groups without disturbing the school.
However, it may be mentioned that these sections A and B

were the outcome of a random distribution done at the lower level at the time of admissions. Therefore, no intentional grouping had been done in the school for any of the sections. In the normal course, children are given admission at the Class I level and the sections are determined at that time randomly; and as years roll on they reach these higher classes. Hence, no bias could be attributed to the division of the class into two sections at the time of admissions.

The instructional strategy was implemented by a team of two teachers with fairly good experience in teaching at the secondary level. The investigator himself and a senior colleague constituted the team. The entire strategy was discussed with the second teacher as part of teacher orientation. The teachers were exchanged between sections A and B after half the programme was over in order to remove any teacher variable influencing the achievement scores. The measurement of effectiveness involved the administration of a common criterion test at the end of each topic and comprehensive test at the end of the programme. The combined criterion test scores and annual examination scores were also taken into account for comparison. Usual statistical techniques like mean, median, standard deviation, etc. were employed to analyse the data

obtained. Since no prematching of groups was done
analysis of covariance was adopted for adjusting the
mean values on the combined criterion test scores,
comprehensive test scores and annual examination scores
with previous class annual examination scores as the
covariate.

The data obtained in the experiment to verify
the effectiveness of the strategy was also used later to
examine the hierarchy in learning, described in Chapter V.
A cognitive preference test with twenty items was
administered as pretest before the start of the programme
and post-test after the programme was over, to both the
groups and an analysis was done to test the changes in
preferences as described in Chapter VI.

5.3   Sample

The sample selected for the study was the
students of Class IX of a higher secondary school in
Baroda. The school is affiliated to the Central Board
of Secondary Education, New Delhi and is a member of the
Indian Public Schools Conference. The school follows the
All India Secondary School Syllabus with science compulsory
to all till the end of secondary level. Class IX had two
divisions- A and B, with 38 and 37 students in them. As

mentioned earlier, the students were those who had been admitted to the respective sections at the lower level (say class I) and as such could be taken to have been randomly distributed. One section was randomly selected as the experimental group and the other was assigned as control group.

5.4   Treatment

The classroom management, after having developed an instructional strategy, involved making use of the principles described in the preceding chapters and a detailed planning in terms of teacher and student activities so that the student may reasonably progress from one lesson to the next without fattering along the way. The 'how to instruct the learner?', involves planning of instructional events which may take variety of forms that may require the teacher participation to a greater or lesser degree. In a basic sense the instructional events designed will include a set of transactions with the student.

The experimental group was provided with the instructional events in accordance with the conditions of learning as enunciated by Gagne. Gagne (1968) lists

some of the instructional events in a lesson, given in the approximate order in which they are employed :

1. Gaining attention
2. Informing the learner of the objective
3. Stimulating recall of pre-requisite learnings
4. Presenting the stimulus material
5. Providing 'learning guidance'
6. Eliciting performance
7. Providing feedback about performance correctness
8. Assessing the performance
9. Enhancing retention and transfer.

These events were described in the earlier chapters. The events as Gagne (1974) notes, do not invariably occur in this exact order, although this is the most probable order. Even more important, by no means all these events need be provided for every lesson. Though the exact form of communication may differ from topic to topic the classroom strategy adopted for the experimental group employed almost the same events as mentioned above.

Initially all the students of group A (experimental group) were given an orientation towards the instructional strategy being followed during the experiment. The main

points discussed in this orientation programmes were as follows :

1. What the instruction is about ?

2. Familiarising with the learning materials i.e., classroom learning material (CLM), home assignment material (HAM) and assessment material (AM).

3. A continuous evaluation through question-answer and discussion at the end of every element (any concept or rule·).

4. Self evaluation at the end of each topic.

5. Assessment at the end of the topic (the criterion test).

6. A comprehensive test at the end of the experiment.

The students were told clearly about the differences between group A and Group B. They were also asked not to pass on any of the learning material to the control group (Group B). Familiarisation with the learning material was done through a discussion on CLM and HAM; objectives, task analysis Map, hierarchy model, how the Structure of the

elements are treated, evaluation at the end of each
concept or rule etc. All the students were instructed to
utilize their freedom to raise any questions or doubts.
They were also informed that we were aiming at a mastery
learning at every stage. Though the answers for the
questions in the Home Assignment Material were provided
at the back of the material they were asked not to see them
before actually working out the problems. In fact, they
were to be used only to verify their results.

Various methods were used to gain the attention
of the learners. This included, discussion on the range of
speed of a cycle to the modern rockets in the topic of speed
and velocity, the history of Newton's laws, common examples
of conservation aspect, a world with no friction etc.
Normally this was done with a short introduction and then
asking a question like 'What do you think the reason for
the bodies falling down?', in the gravitational section.
Many questions depended on the discussion that had taken
place on that particular day and as such one could not
provide a set of standard questions or procedures. It was,
however, ensured that these introductions were interesting
and informative as to draw the attention of the students.

It was considered important that the learner should know the kind of performance which was to be used as indicators that learning had been accomplished. These performance objectives or learning objectives as they were called had been clearly spelt out in the classroom learning material (CLM) supplied to the students. Normally when a topic was completed the students were asked to read through the objectives of the next topic at home as part of their home preparations. This did not mean that the instructor took the chance of assuming that the students know what the objectives of the lesson were. These objectives were effectively communicated to the students in the class before the start of every topic.

The next step was to explain the task analysis map and learning hierarchy to the students. The task analysis maps discussed initially were in terms of concepts and rules. Basically this gave the students an idea about the structure of the topic and the elements involved and their order for accomplishment. It clearly showed them the number of elements, the rules linking them and how the topic was actually evolved. The pyramidal hierarchy with problem solving at its apex could prompt them to orient their attention to problem solving methods. The learning hierarchy which was more discriptive with learning

objectives arranged in hierarchical order, were then explained to them. These hierarchies which enforced precise behavioural definition of the terminal skill were explained to them as the route to successful performances.

Recall of pre-requisite capabilities are essential for any successful learning. In the first topic, all the elements were dealt with but as one moved to newer topics many of the elements appeared as reviewing concepts. For example for topic III, Newton's First and Second Laws, four concepts were given under the caption 'concept revision'. Thus, the learning of Newton's laws also involved all these four elements- time, displacement, velocity and acceleration. These had to be mastered first if the learning was to be successful. Their accessibility was assured by having them recall just before the new learning took place. The recall of previously learned capabilities were stimulated in the classroom by a communication which required the students answer recognition or better recall questions like, "Do you remember what is acceleration?" Or "What is the unit by which acceleration is measured?" etc. which referred to elements learnt under the earlier topics.

Presenting the material consisted in the actual instruction of various concepts and rules. The concepts or

elements were taken up one by one and discussed
extensively to clear any doubt. Students were also
encouraged to ask questions during the teaching. At the
end every element, concept or rule, evaluation was done
through oral questions and this was necessary to make sure
of the attainment of that particular element. If, after the
evaluation, it was felt that sufficient understanding was
not there, the concerned element was discussed again. The
stimulus presentation for the learning of concepts and
rules were done through a variety of examples. So that the
attributes regarding each one was clear. Once the concepts
and rules were learned the learners were made to do problem
solving. Employing a variety of examples in problem solving
the learners were made to use the previously acquired
capabilities in concepts and rules.

Guidance was also provided to the learners to
solve problems on their own. The amount of guidance, i.e.,
"the direct or indirect prompts", obviously varied depending
upon the type of problem and its difficulty level. Hints-
a slight indication, a faint or indirect suggestion, usually
given orally - were given as and when required while solving
problems. The discussion on a problem usually was done in

the following way :

1. What are the information provided in the problem?

2. What are we supposed to find out?

3. Is there any equation connecting all

   these information?

4. Substitute the values and calculate.

These types of hints were given while solving of problems. It may be noted that the hints given at the time of solving problems were not the same always and also not given with all the problems.

Eliciting the performance is actually achieved by initiating the learner usually through such statements as "Let me see, how you do the problem; go ahead" etc. The learner not only should convince others that he has achieved the capability but also should convince himself. An independent performance was expected of the students on saying "do it". Thus many steps were adopted to coax the children to do the work through guided methods as well as independently: The communications from the instructor 'show me'; 'do it'; 'let me see', were intended to see that the learner applied the capabilities already gained by him to new instances.

Feedback was provided at different stages as under :

(1) at the end of every element,

(2) at the end of home assignment,

(3) at the end of assessment.

The internal continuous evaluation and the immediate feedback as to its correctness at the end of each element was a very important component of the instructional strategy employed. This involved, inferring the learner about the correctness of the answer, pointing out the mistakes, providing clarification about any confusion therein and giving additional explanation in case of insufficient comprehension. The answers at the end of HAM provided immediate feedback but any general difficulty arising when answering the same was further discussed in the next class. Corrected answer papers were given to the learners after the assessment test. Again all the difficult problems were discussed in the class.

To enhance retention and transfer the self-learning/ evaluation material (HAM) was provided. This contained items based on every intellectual skill to be achieved. Various examples and questions provided ample opportunity for the learner the practice of which was essential for their retrieval. The concept mastery or rule mastery depended

upon the easy recallability of various information
about relevant concepts. Therefore the HAM highlighted
many of the attributes responsible for the formation of
a concept or a rule. Provisions were also made for the recall
of intellectual skills through reviewing previous concepts
when a new topic was taught in the class. As for the
assurance of transfer of learning, it was done by setting
a variety of new tasks for the learner-tasks which required
the application of what had been learned in situations that
differed substantially from those used for the learning
itself. Problem solving tasks in the HAM provided for this.

The control group was supposed to have their
teaching learning situation in the traditional way. As
usual, textbook formed the main resource material for them.
No additional learning material was provided. They were not
specially made aware of any learning objectives. Lecture
method was used in the class. Discussions were minimum. There
was no continuous evaluation. The time spent for completing
each topic was maintained to be same as that of Group A.

The assessment at the end of each topic was common
to both group A and group B. These were done through
criterion tests to be answered in one period. Each test

consisted of three parts : Part A - for concepts, Part B - for rules and Part C - for problem solving with equal weightage given to each part. After marking the papers, they were given to the students of both the sections, difficulties were explained and doubts cleared. When the whole experimental instruction was over, a comprehensive test was administered to both the groups. Though the results of the comprehensive test were given to students they were not discussed.

A general discussion was conducted at the end of the session (i.e., after the experiment was over) in Group A to find out the reaction of the students to the whole exercise. The discussion was more informal and not binding on any one. The whole experiment took about three and a half months to complete.

5.5 Data Collection

The data required for validating the instructional strategy, developed and used, as required under objective No.2, was obtained through eight criterion tests conducted at the end of each topics, one comprehensive test towards the end of the experiment and the annual examination at the end of the academic year. Each criterion test was divided

into three sections: A-.for concepts, B- for rules
and C- for problem solving. Each section was given equal
weightage. All the criterion tests were conducted for the
same duration of time, carried equal marks. Each test was
marked for a maximum of 30 marks (10 each for section)
and the results were converted to percentages for the
purpose of analysis. The comprehensive test and annual
examinations were of longer time duration and the results
of which were also converted to percentages. The combined
criterion test scores were also used in the analysis.
Criterion test No.4 had only concept level question and as
such it was dropped for further analysis at rule and problem
solving level. As the groups were not matched the annual
examination score of the previous year (at the end of Std.VIII)
was taken as covariate for adjusting the mean scores in the
analysis of covariance.

5.6   Data Analysis

The data collected through various tests described
earlier were analysed using usual statistical techniques.
The analysis was done under the following three sections :

(i) Analysis of individual tests,
(ii) Capability level analysis,
(iii) Analysis of covariance.

Apart from the usual analysis in terms of mean mode, median, percentile etc. graphical representation were also made use of for a better comparison between the experimental and control group.

5.6.1 Analysis of Individual Tests

At the end of every topic a criterion test was held to find out the performance of each student. These criterion test results are analysed in this section. Such an analysis tells us not only about the efficacy of the instructional strategy but also gives us the feedback with vital clues regarding the strengths and weaknesses of the instructional strategy particularly the software component and thereby help to improve the strategy itself.

The discussion on the criterion test scores is done using the frequency distribution of scores for various class intervals. The arithmetic mean and standard deviation values also formed part of the analysis. For interpretation purposes the following criterion was formulated, taking into consideration the regulations of Central Board of Secondary Education (CBSE, New Delhi) also, as the school was affiliated to CBSE.

0 - 32%   Poor Performance

33 - 49%   Fair Performance

50% - 59%   Average Performance

60% - 74%   Good Performance

75% -100%   Outstanding or Excellent Performance

33% was considered also as the minimum score required for a pass and score between 90-100 was taken as a mastery level performance. Study was also done using graphical representations given in the following sections. The individual scores on 5 high achievers and 5 low achievers, taking the Ist Test as base, were analysed to see whether the instructional strategy helps any one of these groups, in particular.

For the purpose of the learning material improvement, the over-all distribution of the achievement scores on individual criterion test has been taken as the main basis. No attempt has been made to analyse specific errors committed by students on the criterion test. However, the data were augmented by the points that emerged during the detailed feedback session that were held to discuss the answers to home assignment material (HAM) and at the end of each test which took into account the difficulties faced by the students with respect almost all questions.
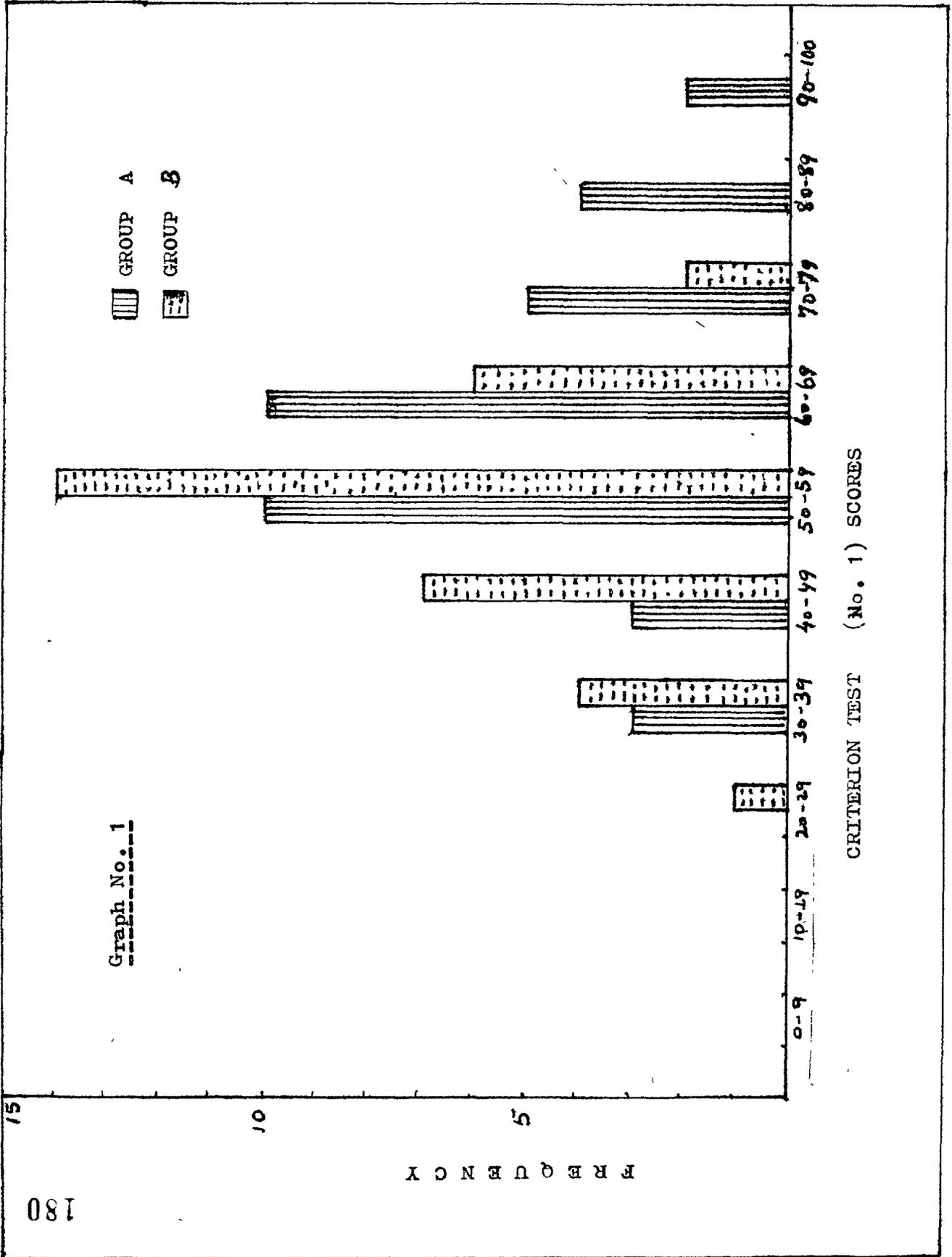
(a) <u>Individual Criterion Test Scores</u>

The result of first criterion test administered
at the end of topic No.1 : is given in Table No.1. The
frequency distribution table showed clear cut difference
between the scores of the experimental Group A and the
control Group B. Group A values shows no score below the
passing percentage of 33% while there are 3 such cases in
Group B, exhibiting poor performance. There were nine cases
of scoring above 75% in Group A while there is none in
Group B showing excellent result. The cumulative frequency
values show that there were only 16.22% of students getting
below 50% score in Group A while corresponding value in
Group B is 35.29%. The mean score of Group A was higher
with a value of 62.08% as compared to that of Group B which
was 50.68%. Group A also had a higher median value with 60
as compared to 51.65 of Group B. Graph No.1 for the first
criterion test showed the scoring pattern of Group A and
Group B. Group A values clearly stand towards the higher side
compared to that of Group B. The modal class for Group A
was bimodal with equal frequency in the class interval 50-59
and 60-69 while in the case of Group B, it was 50-59 class
interval. The histogram showed a fair distribution of
scores in the case of both Group A and Group B around their
respective   median values. Group A values showed more

Table No.1 :   Frequency Distribution
Criterion Test No.1

Scores	GROUP - A			GROUP - B		
C.I.	f	cf	cf in percentage	f	cf	cf in percentage
0-9	0	0	0	0	0	0
10-19	0	0	0	0	0	0
20-29	0	0	0	1	1	2.94
30-39	3	3	8.11	4	5	14.71
40-49	3	6	16.22	7	12	35.29
50-59	10	16	43.24	14	26	76.47
60-69	10	26	70.27	6	32	94.12
70-79	5	31	83.78	2	34	100.00
80-89	4	35	94.59	0	34	100.00
90-100	2	37	100.00	0	34	100.00
0-32	0	0	0	3	3	8.82
33-49	6	6	16.22	9	12	35.29
50-59	10	16	43.24	14	26	76.47
60-74	12	28	75.68	8	34	100.00

Arithmetic Mean	62.08		Arithmetic Mean	50.68
Median	60.00		Median	51.65
Sample S.D.	15.62		Sample S.D.	11.36

Graph No. 1

GROUP   A
GROUP   B

FREQUENCY

15

10

5

0-9   10-19   20-29   30-39   40-49   50-59   60-69   70-79   80-89   90-100

CRITERION TEST   (No. 1)   SCORES

variation with its standard deviation value of 15.62 compared to that of Group B for which the value of S.D. was 11.36 . Mean score of Group A is the lowest among all its mean scores which indirectly suggest a revision in our strategy.

Though there were only 6 students from Group A getting less than 50% in aggregate a closer look at their individual scores showed that there were 8 students getting 20%, 3 students getting 30% marks in problem solving and similarly about 16 students were getting 40% or less in rules. They had done well at the concept level. This demanded that more illustrations may be given at the rule level and some more guided problem solving exercises. Problem solving, needed more attention. The assessment item in Section B (rules) contained only application level questions. That would have made these items difficult for the average students and hence a low score. Discussion at the end of self learning material showed that they liked it, but it could have included some problems also; which were not there. Thus, the feedback at the end of the topic are revealed that (i) problems should be included in the self-learning material and (ii) more illustrations at the rule level should be given in the class.

Table No.2 gives the frequency distribution for criterion test No.2 administered at the end of topic No.2 . There was only one case of poor performance, by scoring below 33%, in group A while there were 14 cases in group B. 41.18% of students in group B failed to get passing marks as compared to 2.7% of group A. Only 13.51% scored below 50% in group A, while it is 85.29% in group B. This means that for test No.2 the control group shows a below average performance as almost 29 students out of 34 students had a score below 50%. 13 students in group A show excellent performance while there was one such case in group B. There were 3 students in group A who scored between 90 and 100 which we can consider to be the mastery achievement level while there was none in group B. Group A has done very well compared to group B which is evident from the arithmetic mean value of 66.13 and 37.36 respectively. Graph No.2 shows that the group A distribution is skewed towards left while for group B it is skewed towards right. It clearly indicated highly favourable results exhibited by experimental group. The graph shows that modal class falls in the class interval of 30-39 for group B while it is 50-69 in the case of group A. The mean scores shows that group A improved its performance while group B has gone down. In fact this was a good progress for group A considering that out of the six concepts 4 were

Table No.2 :   Frequency Distribution
               Criterion Test No.2

Scores C.I.	GROUP - A			GROUP - B		
	f	cf	cf in Percentage	f	cf	cf in Percentage
0-9	0	0	0	0	0	0
10-19	0	0	0	0	0	0
20-29	0	0	0	9	9	26.47
30-39	1	1	2.70	13	22	64.71
40-49	4	5	13.51	7	29	85.29
50-59	8	13	35.14	2	31	91.18
60-69	8	21	56.76	2	33	97.06
70-79	7	28	75.68	0	33	97.06
80-89	6	34	91.89	1	34	100.00
90-100	3	37	100.00	0	34	100.00
0-32	1	1	2.70	14	14	41.18
33-49	4	5	13.51	15	29	85.29
50-59	8	13	35.14	2	31	91.18
60-74	11	24	64.86	2	33	91.18
75-100	13	37	100.00	1	34	100.00 -

Arithmetic Mean	66.13	Arithmetic Mean	37.36
Median	63.30	Median	35.0
Sample S.D.	16.59	Sample S.D.	14.45

Graph No. 2

GROUP A
GROUP B

FREQUENCY

CRITERION TEST (No. 2) SCORES

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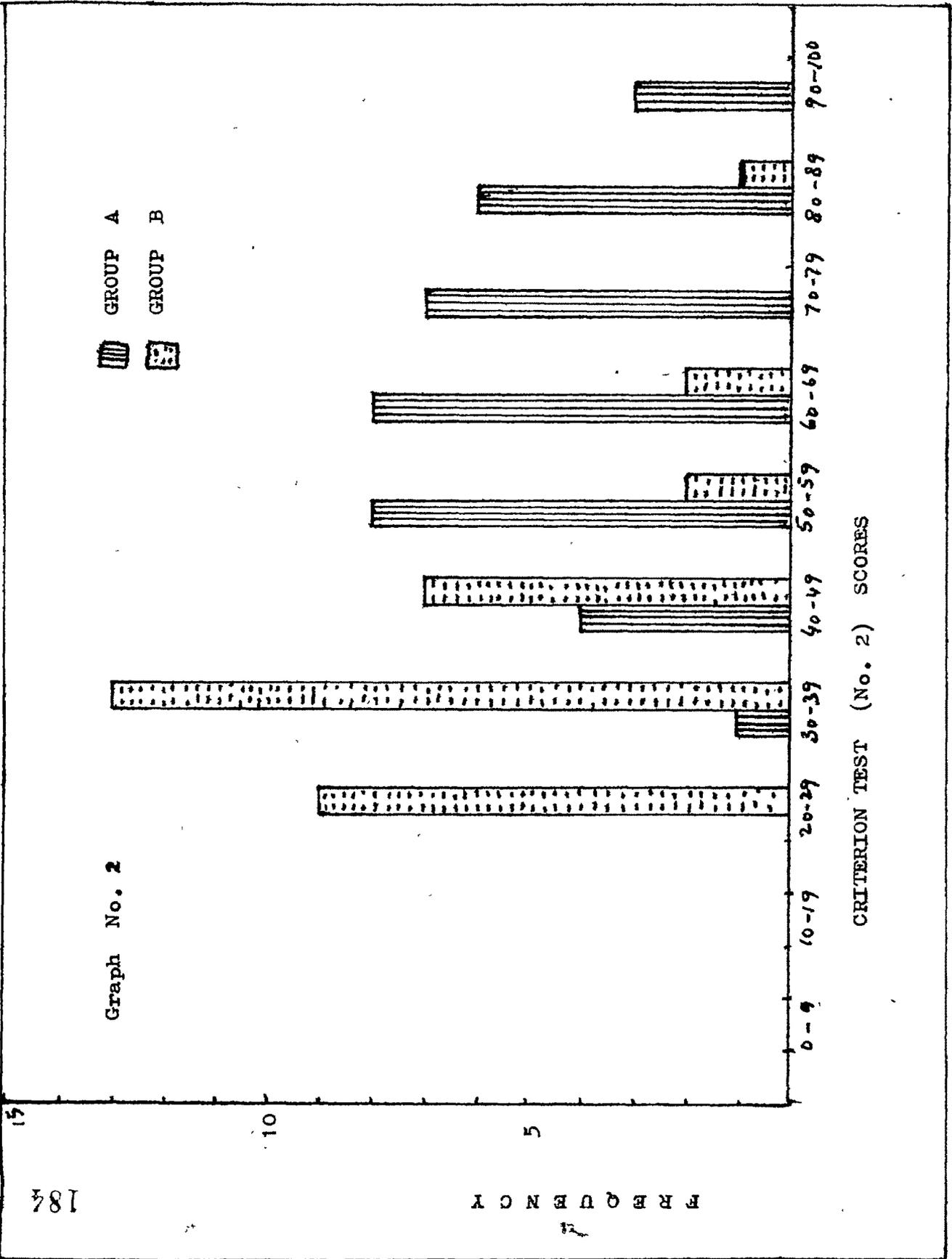
treated as reviewing concepts as they were covered under the previous topic.

Individual analysis of the scores show that there were 9 students getting less in section B of the assessment compared to section C. This evidently point towards something lacking at the rule level. A further discussion on this with the students showed that there was no exercise in the self learning material based on equations of motion which was then taken care of. Also question No.1 and 2 in the self evaluation section was found too difficult or too vague for the students and hence it was decided to delete the same.

The results of 3rd criterion test administered at the end of topic No.3, Newton's Laws I & II is given in table No.3. Group A values show poor performance in 2 cases (5.41%) as compared to only one (2.94%) case in group B. But there are only 5 students (13.51%) in group A with below average performance as compared to 12 students (35.29%) of group B, scoring below 50%. There were 14 students showing excellent results scoring about 75% in Group A while there was none in group B. 4 students of group A scored between 90 and 100 while there was none in group B belonging to this category. While 63% of the students in group A showed

Table No.3 : Frequency Distribution
Criterion Test No.3

Scores C.I.	GROUP - A			GROUP - B		
	f	cf	cf in percentage	f	cf	cf in percentage
0-9	0	0	0	0	0	0
10-19	0	0	0	0	0	0
20-29	1	1	2.70	0	0	0
30-39	2	3	8.11	3	3	8.82
40-49	2	5	13.51	9	12	35.29
50-59	5	10	27.03	12	24	70.59
60-69	8	18	43.65	8	32	94.12
70-79	8	26	70.27	2	34	100.00
80-89	7	33	89.19	0	34	100.00
90-100	4	37	100	0	34	100.00
0-32	2	2	5.41	1	1	2.94
33-49	3	5	13.51	11	12	35.29
50-59	5	10	27.03	12	24	70.59
60-74	13	23	62.16	10	34	100
75-100	14	37	100	0	34	100

Arithmetic Mean	67.21	Arithmetic Mean	51.65
Median	70.00	Median	53.30
Sample S.D.	16.73	Sample S.D.	10.61

Graph No. 3

GROUP A
GROUP B

CRITERION TEST (No 3) SCORES

FREQUENCY
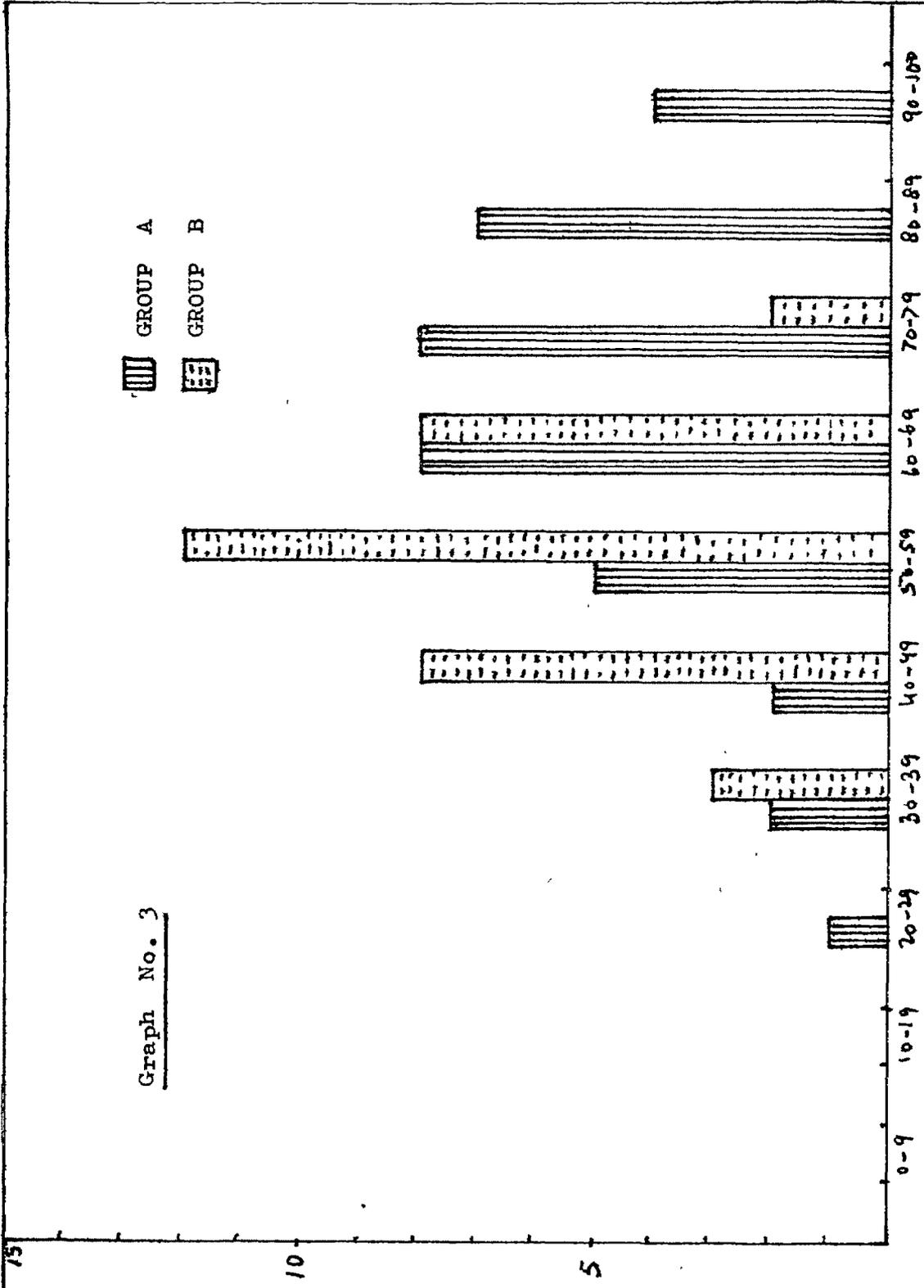
good performance scoring above 60% there was only
29.4% students in this category in group B. The
arithmetic mean value shows a fairly high score of 67.21
for group A and a moderate value of 51.65 for group B.
More variation in the scoring pattern was noticed in the
case of group A with a S.D. value of 16.73 compared to that
of group B with a value of 10.61. Graph No.3 shows an
average scoring pattern for group B compared to a high
scoring level in group A. The modal class falls within 50-59
range for group B while it was bimodal is 60-79 range for g
group A. Both the groups have improved their performance.

Out of the five students scoring less than 50%
in group A there are 3 getting zero at the problem level.
Though the graph No.14 shows a steady level for problems
at this level the material, it seems needs improvement. The
scoring at the rule level had come down slightly. Self
learning material did not contain any exercise on the
derivation of f = ma which might have led to the low
scoring at the rule level. Otherwise in topic 3 the
strategy adopted has shown good results which is evident
from group A achievement.

Table No.4 gives the frequency distribution for
the fourth criterion test scores at the end of topic No.4.
Newton's 3rd Law of motion. This particular test

Table No.4 :   Frequency Distribution
Criterion Test No.4

Scores C.I.	GROUP - A			GROUP - B		
	f	cf	cf in percentage	f	cf	cf in percentage
0-9	0	0	0	0	0	0
10-19	0	0	0	0	0	0
20-29	1	1	2.70	0	0	0
30-39	4	5	13.51	5	5	14.71
40-49	2	7	18.92	2	7	20.59
50-59	3	10	27.03	8	15	44.12
60-69	0	10	27.03	5	20	58.82
70-79	0	10	27.03	1	21	61.76
80-89	9	19	51.35	6	27	79.41
90-100	18	37	100	7	34	100
0-32	5	5	13.51	5	5	14.71
33-49	2	7	18.92	2	7	20.59
50-59	3	10	27.03	8	15	44.12
60-74	0	10	27.03	6	21	61.76
75-100	27	37	100	13	34	100
Arithmetic Mean			74.32			62.94
Median			80.00			60.00
Sample S.D.			24.33			22.50

Graph No. 4

GROUP A
GROUP B

CRITERION TEST (No. 4) SCORES

FREQUENCY

190
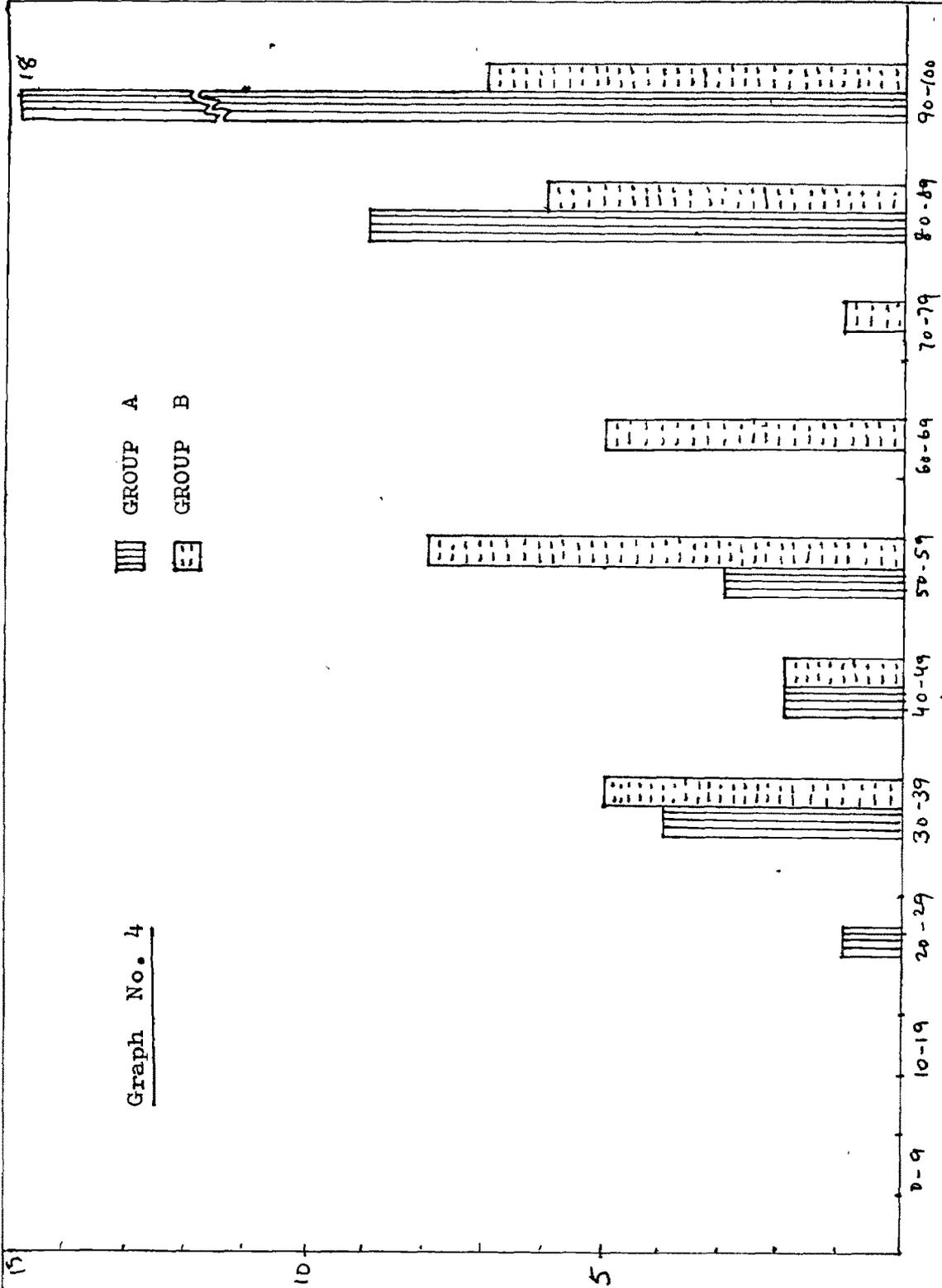
contained only concept level items and the values show good scoring both in group A as well as group B. In both the group there were 5 students each getting less than 33% showing poor performance. On the other hand there were 27 students (77%) in group A and 13 students (38.3%) in group B getting more than 75% marks showing outstanding results. There were 18 students in group A and seven students in group B reaching the mastery level performance by scoring more than 90% marks, only 18.92% of the students score less than 50% in group A as compared to 20.59 in group B. The arithmetic mean value of group A was 74.32 while it was 62.94 for group B. The graph No.4 shows that the group A distribution is skewed towards left showing an excellent scoring pattern. The modal class for group A falls within the class interval of 90-100 showed the mastery level achieved by most students in the class for that particular topic. The modal class for group was 50-59. The high scoring pattern exhibited in this test was due to the fact that the test items contained only concept level questions. Evidently concept capability comes at the bottom of the difficulty level also as compared to rule capability and problem solving capability. As the questions are set for higher learning capabilities their difficulty level also increases. Therefore, test No.4 was a case where a number of students scored above average with low difficulty level questions.

it can also be due to the fact that the number of
elements involved were less as compared to other
assessment topics. At the same time this was the lowest
mean score at the concept level. This is due to the fact
that about 7 students scored less than 50%. This type
of result points towards something; "Is the strategy
helping more the high achievers than the low achievers?"
A final analysis can tell us the same.

The frequency distribution in the case of
criterion test No.5 for the topic conservation of
momentum is given in table No.5 .   This was a test in
which a clear distinction was drawn between group A and
group B. The arithmetic mean value of 69.28 for group A
and 49.92 for group B is an indicator towards the better
performance of the experimental group compared to that
of the control group. The mdedian value also shows a high
score of 73.30 for group A as compared 41.65 of group B.
The variation in the scoring pattern is the same for group
A and group B. There was just one case in group A
getting a score below 33% but in there were 11 such cases
(32.35%) in group B. There were 18 cases (42.6%) in
group A showing outstanding results by scoring above 75%

Table No.5 :   Frequency Distribution
Criterion Test No.5

Scores C.I.	GROUP - A			GROUP - B		
	f	cf	cf in percentage	f	cf	cf in percentage
0-9	0	0	0	0	0	0
10-19	0	0	0	0	0	0
20-29	0	0	0	5	5	14.71
30-39	1	1	2.70	11	16	47.06
40-49	9	10	27.03	4	20	58.82
50-59	4	14	37.84	2	22	64.71
60-69	3	17	45.95	4	26	76.47
70-79	3	20	54.05	4	30	88.24
80-89	8	28	75.68	2	32	99.12
90-100	9	37	100	2	34	100
0-32	1	1	2.70	11	11	32.35
33-49	9	10	27.03	9	20	58.82
50-59	4	14	37.84	2	22	64.71
60-74	5	19	51.35	5	27	79.41
75-100	18	37	100	7	34	100
Arithmetic Mean			69.28			49.92
Median			73.30			41.65
Sample S.D.			22.16			22.74

Graph No. 5

GROUP A

GROUP B

CRITERION TEST (No. 5) SCORES

FREQUENCY

194
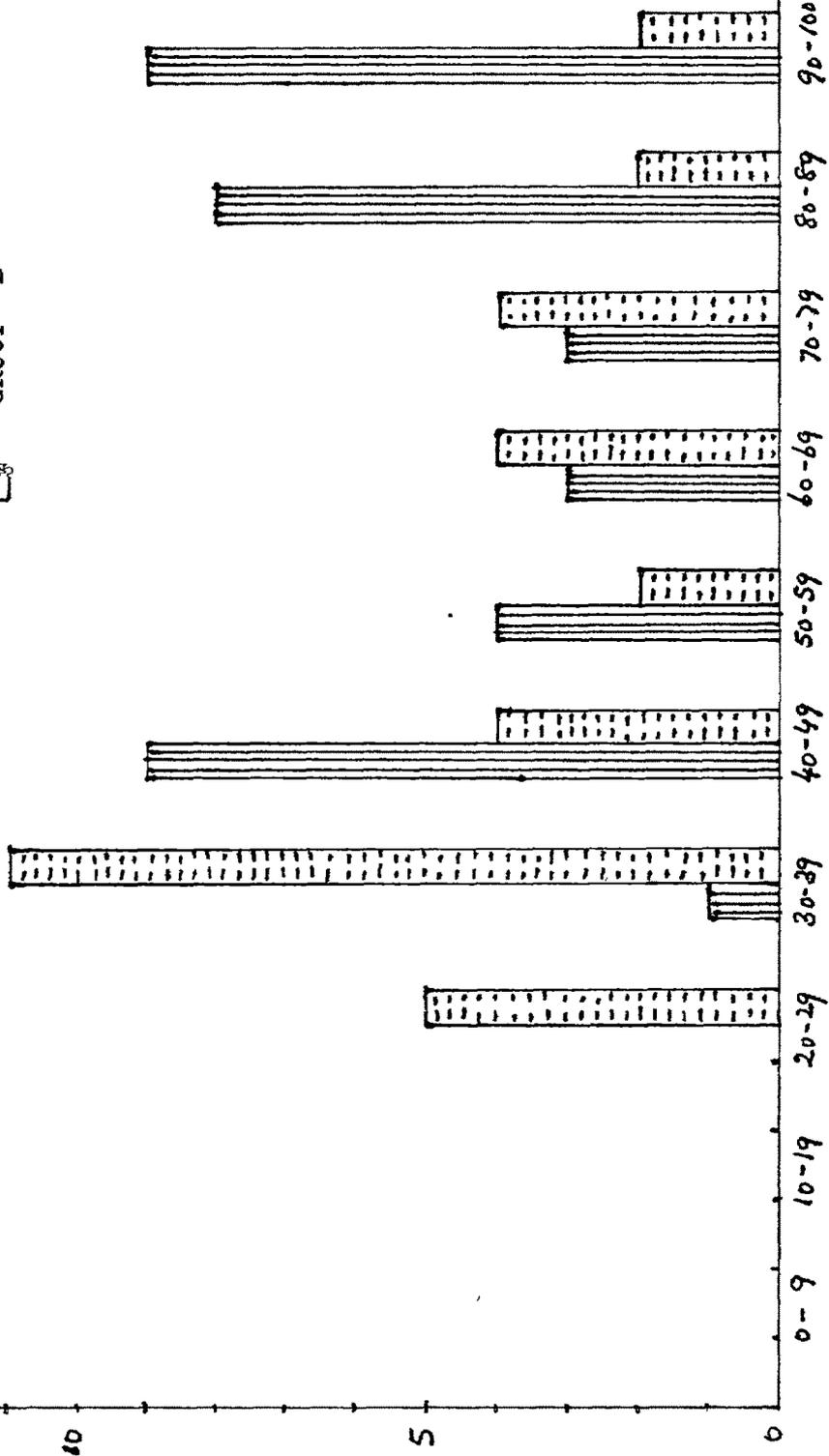
while there was 7 cases in group B belonging to this
category. 9 cases (24.6%) in group A and 2 cases (5.88%)
in group B showed mastery level achievements by scoring
above 90%. The graph No.5 clearly indicates the scoring
pattern in group A and group B. 30-39 class interval
became the model class for group B while it is bimodel
for group A with 40-49 and 90-100 registering the same
value for frequency. The graph shows a special aspect in
group A with two sections: one, mostly to the higher side
of the scoring and the other to the lower side. This is
due to the fact that group A has scored heaving at the ·
concept level with the arithmetic mean reaching 94.1 while
it goes down 58.9 and 57 for rules and problems respectively,
which is discussed later on in this chapter. The dip in the
mean score for group A is not important here as the previous
test contained only concepts. Therefore comparing to the
first three tests we see that the group A was doing well.
This is one test where the strategy has shown tremendous
success.

The results shown in table No.6 is the frequency
distribution of scores obtained for the topic on
gravitation. None of the students from group A failed to
get the pass percentage of 33% but there were four such
cases in group B. There were only 3 students (8.11%) getting

Table No.6 :   Frequency Distribution
Criterion Test No.6

Scores C.I.	GROUP - A			GROUP - B		
	f	cf	cf in percentage	f	cf	cf in percentage
0-9	0	₀0	0	0	0	0
10-19	0	0	0	1	1	2.94
20-29	0	0	0	2	3	8.82
30-39	0	0	0	2	5	14.71
40-49	3	3	8.11	6	11	32.35
50-59	9	12	32.43	5	16	47.06
60-69	6	18	48.65	5	21	61.76
70-79	9	27	72.97	8	29	85.25
80-89	7	34	91.89	3	32	94.12
90-100	3	37	100	2	34	100
0-32	0	0	0	4	4	11.76
33-49	3	3	8.11	7	11	32.35
50-59	9	12	32.43	5	16	47.06
60-74	13	25	67.57	8	24	70.59
75-100	12	37	100	10	24	100

Arithmetic Mean	68.29	59.20
Median	70.00	60.00
Sample S.D.	14.56	25.50

Graph No. 6

GROUP A
GROUP B

CRITERION TEST (No. 6) SCORES

FREQUENCY

197
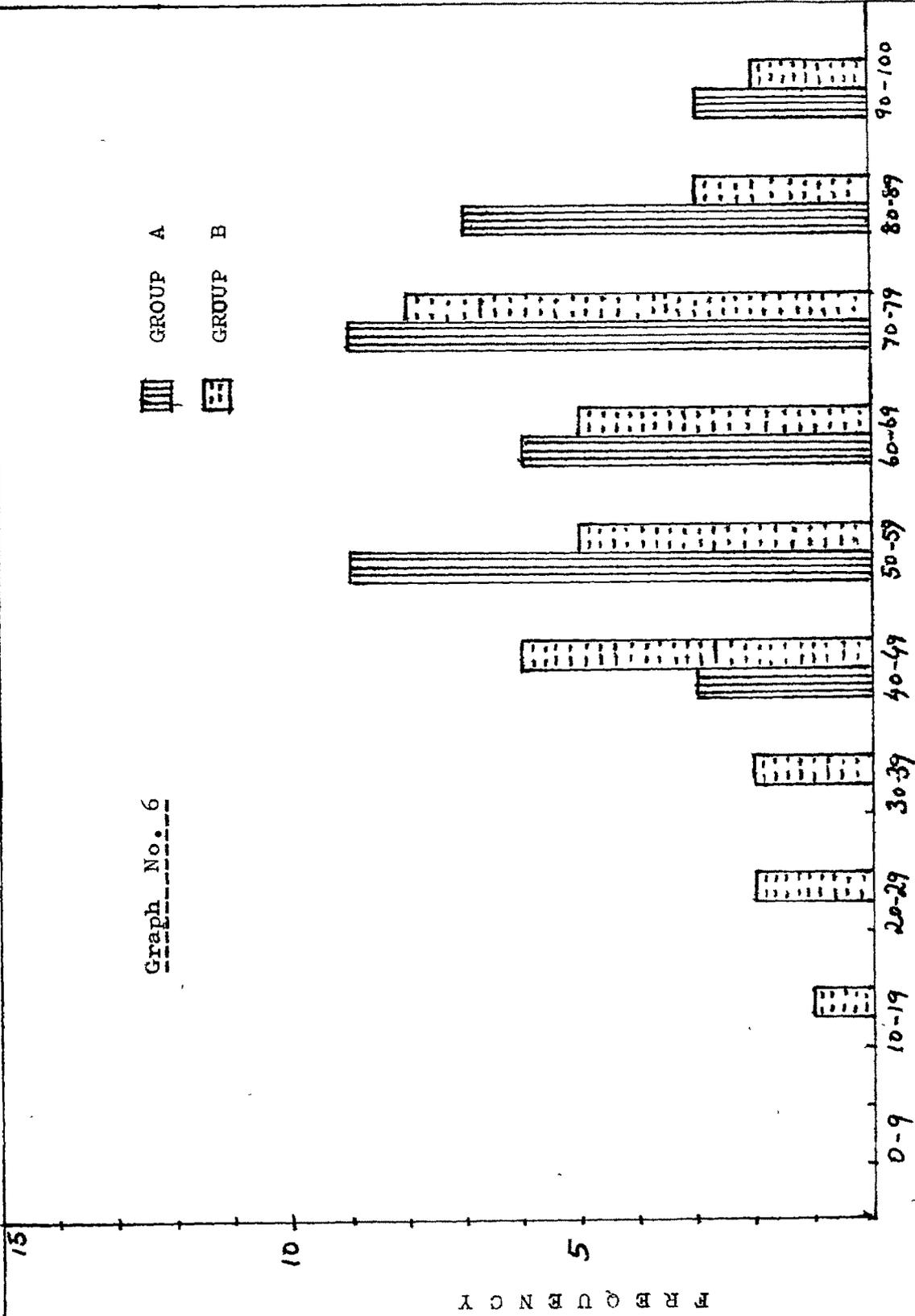
below 50% marks in group A while there were 7 students
(32.35%) belonging to this category in group B. 12 students
of group A and 10 students of group B scored above 75%
showing outstanding achievement. Arithmetic mean of 68.29
for group A and 59.20 for group B showed very good
performance by both the groups. Three students from group
A and two from group B scored between 90 and 100 reaching
the mastery level. Graph No.6 shows that the scoring
pattern of group B was widely distributed. The modal class
for group A was bimodal with highest frequencies falling
between the class intervals 50-59 and 70-79. The model
class for group B was 70-79. Most values, the graph showed,
were towards to higher side exhibiting better achievement.
Scoring here was considered to be better in the sense that
four out of the 8 concepts were discussed in the class as
reviewing concepts since these pre-requisite concepts were
developed in the previous topics. The individual analysis
shows that many in group A has not done well in problems.
Twenty one students scored less than 50%. This suggested
a fresh revision on problem solving was required and more
guided problems are to be included in the self learning
material.

Table No.7 gives the frequency distribution of the scores for the topic friction. None of the students in group A failed to get 33% the required pass percentage but there were 10 students whose score was below this percentage in group B. 8 students of group A and 15 students of group B showed below average performance scoring below 50% . Almost half the number of students of group A (16) scored between 75 and 100 as compared to 8 students of group B belonging to this category. There were 3 students of group A and 4 students of group B who scored between 90 and 100. Arithmetic mean value of group A was 66.31, a good performance, as compared 52.55 of group B. The graph No.7 shows distinctive characteristics between group A and group B. While most of the distribution of group B were towards to left of the graph, it is towards the right for group A. This evidently indicates high scoring pattern of group A as compared to group B. Group B distribution has a bimodal class in 20-29 and 50-59 intervals. For group A the modal class was in 80-89 interval. The mean of both the groups are less compared to the previous and the high S.D. values show lot of variation in scoring. Laws of friction being abstract in nature and problems which are normally more difficult compared to other topics may have contributed towards this change. Lot of practice work

Table No. 7 :   Frequency Distribution
Criterion Test No. 7

Scores C.I.	GROUP - A			GROUP - B		
	f	cf	cf in percentage	f	cf	cf in percentage
0-9	0	0	0	0	0	0
10-19	0	0	0	0	0	0
20-29	0	0	0	7	7	20.59
30-39	2	2	5.41	5	12	35.29
40-49	6	8	21.62	3	15	44.12
50-59	6	14	37.84	7	22	64.71
60-69	6	20	54.05	1	23	67.65
70-79	4	24	64.86	5	28	82.35
80-89	10	34	91.89	2	30	88.24
90-100	3	37	100	4	34	100
0-32	0	0	0	10	10	29.41
33-49	8	8	21.62	5	15	44.12
50-59	6	14	37.84	7	22	64.71
60-74	7	21	56.76	4	26	76.47
75-100	16	37	100	8	34	100
Arithmetic Mean			66.31			52.55
Median			66.70			50.00
Sample S.D.			18.44			23.67

Graph No. 7

GROUP A
GROUP B
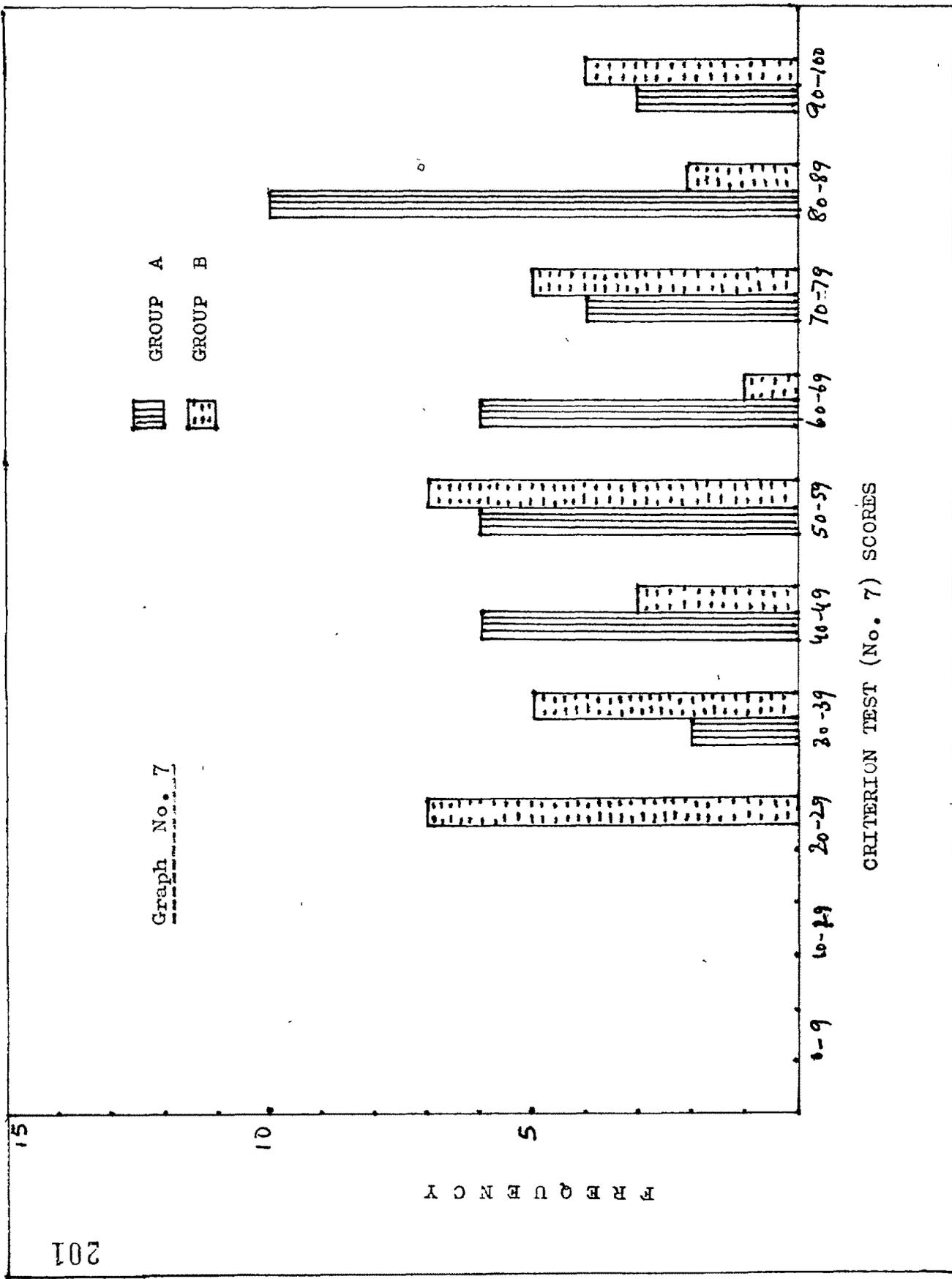
CRITERION TEST (No. 7) SCORES

FREQUENCY

0-9 10-19 20-29 30-39 40-49 50-59 60-69 70-79 80-89 90-100

5 10 15

may be required at this stage to develop problem solving strategies.

Table No.8 gives the frequency distribution for the criterion test om the topic 8 and 9, work and power. One student of group A (2.70%) and two students of group B (5.88%) failed to get the pass percentage of 33%. Group A results show excellent achievement pattern with 19 of the students (51.4%) scoring between 75 and 100 as compared to 4 students of this category in group B. This is an outstanding performance of group A. In fact this could be the result of the whole strategy which was adopted. There were only two students in group A exhibiting below average performance by scoring less than 50% as compared to 5 students belonging to this group in group B. The arithmetic mean reaches a very high value of 73.33 for group A compared to 60.29 of group B. Graph No.8 shows that most of the values are concentrated above 50% level. The modal class of group A falls within the range of 80-89 while for group B it was within the 70-79 range. This result was particularly important in the sense that most of the concept involved were treated as reviewing concepts as they were developed in the previous chapters. The pattern of scoring at different level indicates that more illustrations may be included in the strategy to explain

Table No.8 :   Frequency Distribution
Criterion Test No.8

Scores C.I.	GROUP - A			GROUP - B		
	f	cf	cf in percentage	f	cf	cf in percentage
0-9	0	0	0	2	2	5.88
10-19	0	0	0	0	2	5.88
20-29	0	0	0	0	2	5.88
30-39	1	1	2.70	2	4	11.76
40-49	1	2	5.41	1	5	14.71
50-59	4	6	16.22	7	12	35.29
60-69	7	13	35.14	8	20	58.82
70-79	8	21	56.76	12	32	94.12
80-89	9	30	81.08	1	33	97.06
90-100	7	37	100	1	34	100
0-32	1	1	2.70	2	2	5.88
33-49	1	2	5.41	3	5	14.71
50-59	4	6	16.22	7	12	35.29
60-74	12	16	48.65	18	30	88.24
75-100	19	37	100	4	34	100
Arithmetic Mean			73.33			60.29
Median			76.70			63.30
Sample S.D.			15.70			19.68

Graph No. 8

GROUP A

GROUP B

FREQUENCY

15

10

5

0-9 10-19 20-29 30-39 40-49 50-59 60-69 70-79 80-89 90-100

CRITERION TEST (No. 8) SCORES

204
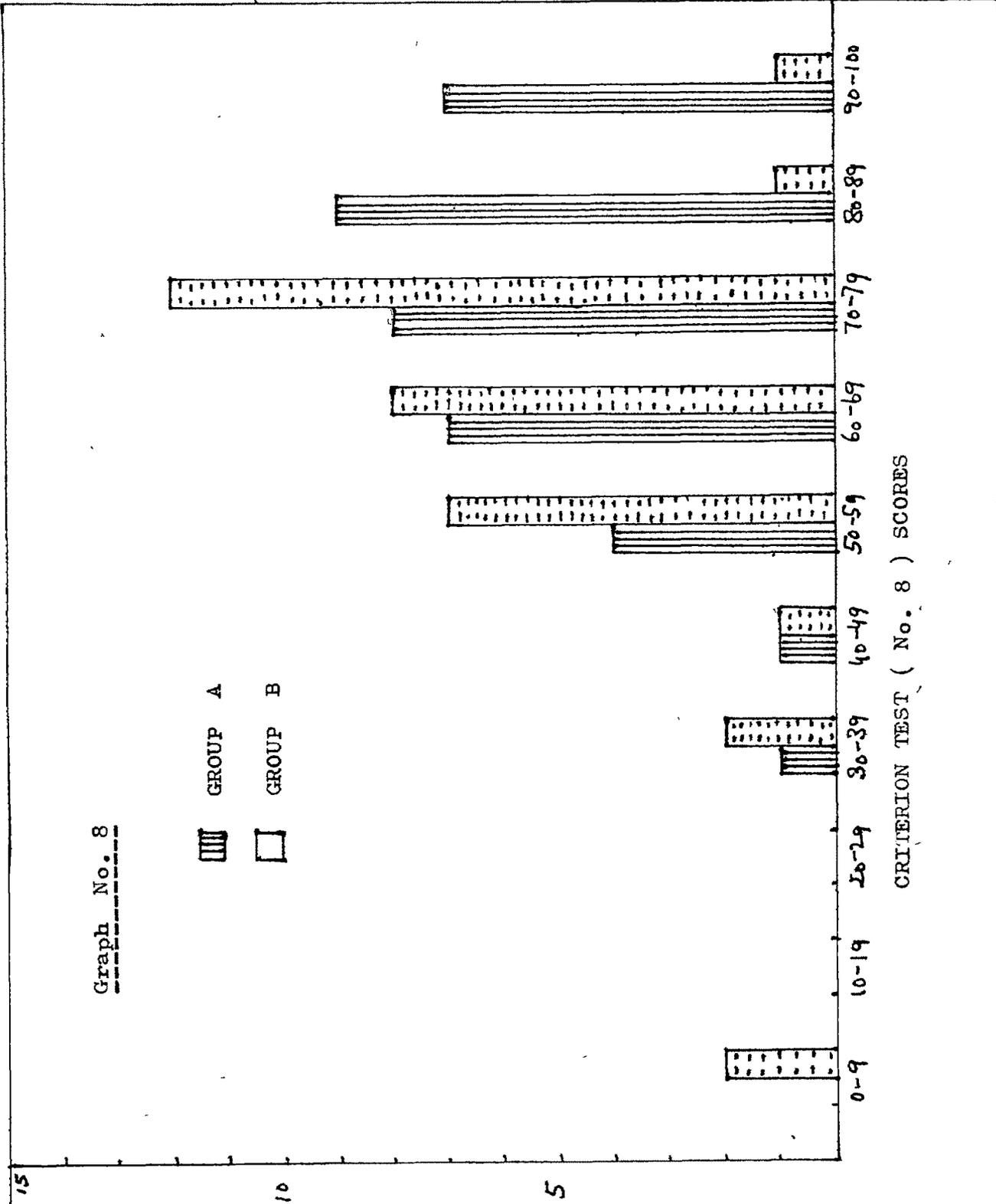
the work done in different circumstances. Because
questions like, "What will be the work done when a
person is carrying a luggage on his head on a level road?",
needed some more explanation. To give the justification
of the answers to the above seemed to be difficult for
the students.

Table No.9 gives the percentile,mean and
standard deviation values on the various criterion tests
conducted. The results shows good results for group A.
Example P_{90} for group A varies between 86 and 98.3 and
for group B it varies between 55.8 and 89.5. In the case
of 2nd criterion test we see that 90% of the scores falls
below 55.8 for group B while for the same test P_{90} value
for group A was 88.8. P_{50} values for group A varies
between 58.85 and 79.9 while for group B this value varies
between 33.2 and 62.5. All these indicate higher scoring
pattern in case of group A. Graph No.9 shows the mean
scores in respect of both group A and B for various
criterion tests. Group A curve clearly lies above Group B
curve. Not for even a single test it overlaps. Group A
curve shows almost a steady scoring pattern while the
curve for group B is more zigzag shaped showing more
variation. The graph is indicating the better scoring
performance by the experimental group as compared to

Table No. 9 : Percentiles, Mean and Standard Deviation Values on Criterion Tests

Topics	I		II		III		IV		V		VI		VII		VIII	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
P_{10}	41.4	31.5	43.3	21.7	44.0	35.3	27.3	6.8	39.5	22.9	47.9	28.5	39.8	23.4	52.3	31.8
P_{20}	46.0	40.0	49.5	24.5	53.5	43.6	41.8	39.5	44.8	26.3	53.2	41.6	49.0	27.3	57.3	43.2
P_{30}	50.6	43.7	54.4	27.3	58.1	45.2	71.7	44.5	49.4	29.7	57.2	46.5	52.3	31.0	62.7	52.5
P_{40}	54.7	47.1	59.0	30.2	63.1	48.9	75.8	48.8	64.5	34.8	61.5	51.7	58.5	39.5	70.1	48.2
P_{50}	58.8	50.5	64.7	33.2	68.4	51.9	79.9	54.5	71.2	40.5	66.1	58.5	66.8	46.5	74.4	62.5
P_{60}	63.3	53.7	70.8	35.1	72.7	54.4	82.8	64.5	76.5	47.3	70.9	65.3	73.3	54.0	78.5	65.9
P_{70}	67.9	57.3	75.4	39.4	76.4	56.8	85.4	75.2	82.8	63.2	76.1	71.5	77.9	64.5	82.9	69.3
P_{80}	74.5	60.7	80.0	46.0	80.1	59.2	88.1	81.0	91.3	72.9	81.5	75.8	82.8	76.0	77.5	73.3
P_{90}	84.9	65.7	88.8	55.8	86.0	65.9	98.3	89.5	95.9	79.7	87.7	80.0	88.1	85.8	93.1	77.5
Mean	62.1	50.7	66.1	37.4	67.2	51.7	74.3	62.9	69.3	48.9	68.3	59.2	66.3	52.5	73.3	60.3
Sample S.D.	15.6	11.4	16.6	14.5	16.7	10.6	24.3	22.4	22.2	22.7	14.6	20.5	18.4	23.7	15.7	19.7

Graph No. 9
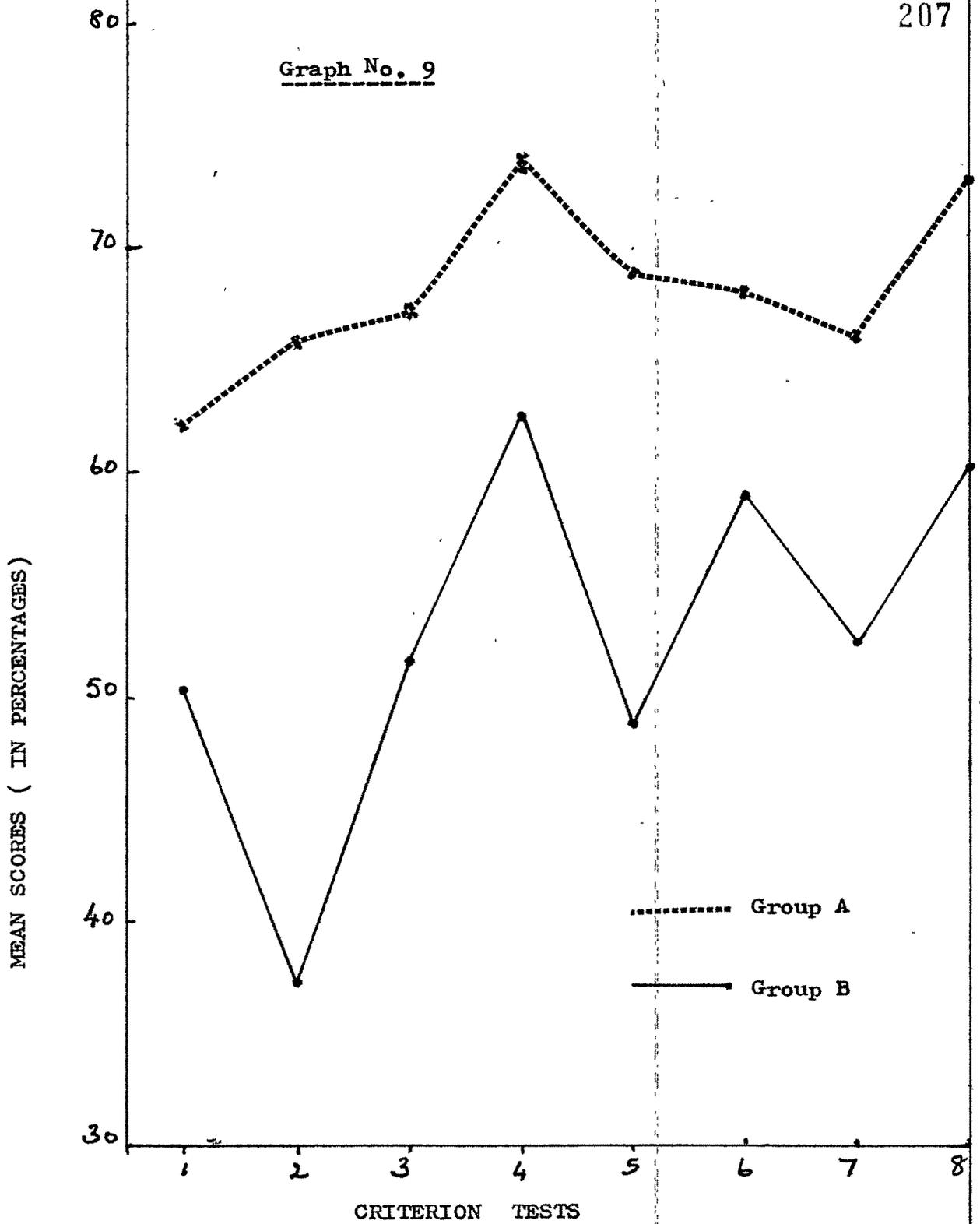
the control group; may be a pointer towards the efficacy of the instructional strategy adopted which will be seen through ANCOVA described towards the end of this chapter.
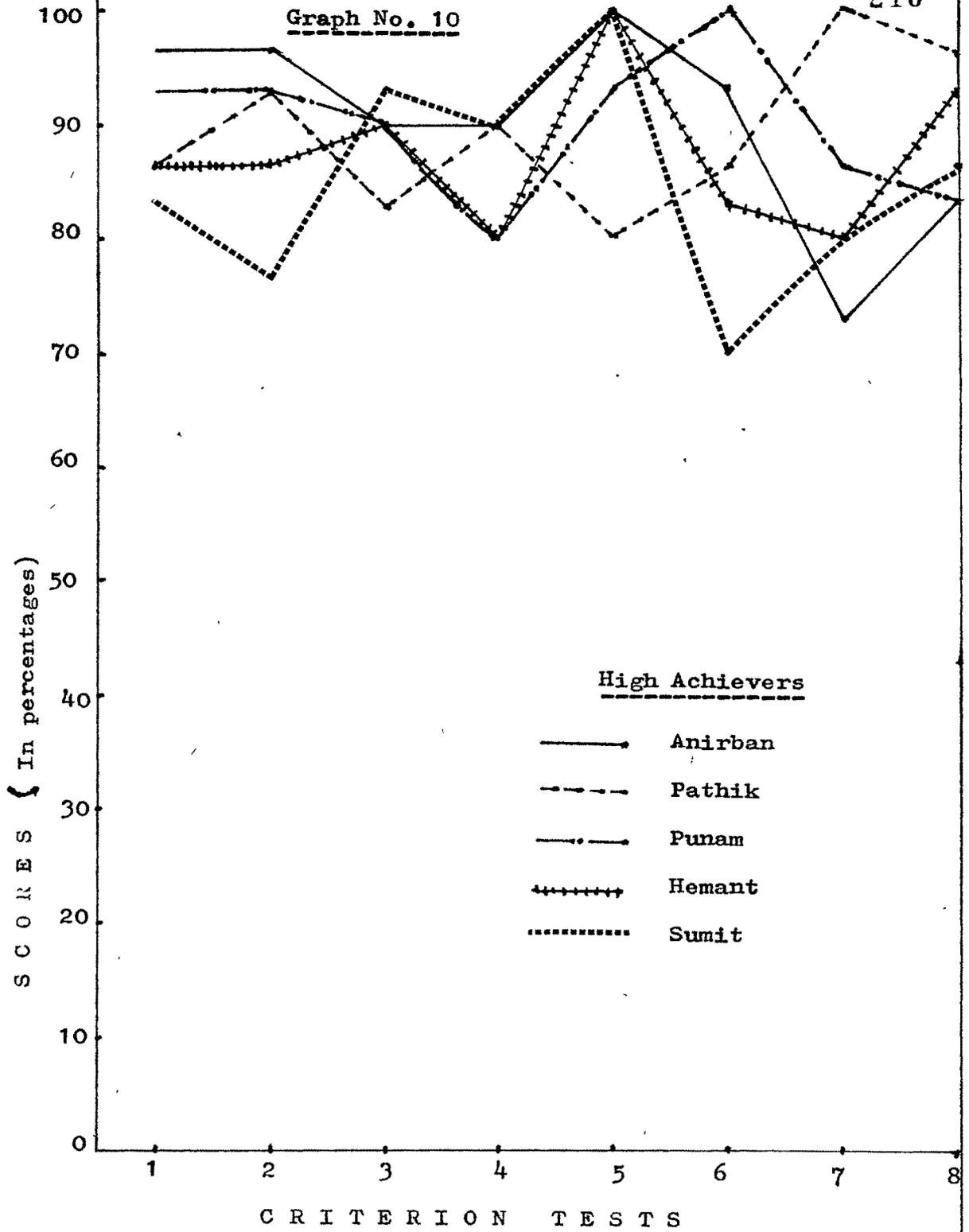
(b) <u>Analysis on the Individual Scores</u>

To see how the instructional strategy has affected both the low achievers and high achievers, 10 students' (5 from each group) scoring pattern was analysed. Table No.10 shows the scores in percentage obtained by these 10 students. For selection of these 10 students the first criterion test was taken as the base. The first 5 in table 10 are those who obtained highest marks in the first criterion test and the last five students are those who obtained least marks in the same. Anirban who got 96.6% in the first test, maintains his marks in nineties except for the last two tests. Similar is the case with all the other students. All of them have scored 100% at least in one test. Therefore with these high achievers, though we can see a slight improvement in the scoring, they cannot go further. So it is a question of maintaining the mastery level which the strategy had helped them to do so. The scoring pattern shown in graph 10 shows a almost a

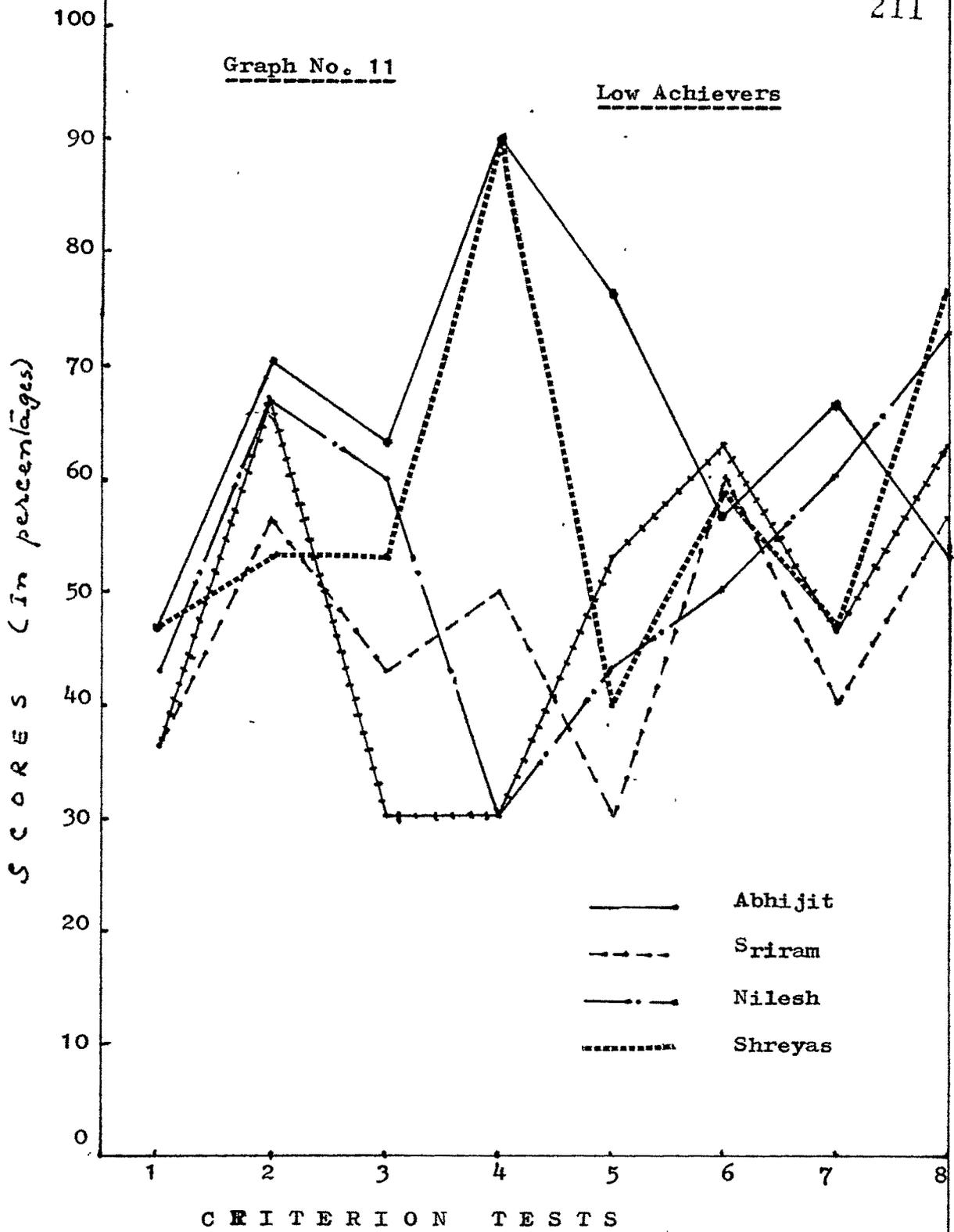Table No.10: High Achievers and Low Achievers of
X̸ No.11
Group A

		CRITERION			TESTS			
	I	II	III	IV	V	VI	VII	VIII

High Achievers

		I	II	III	IV	V	VI	VII	VIII
1	Anirban	96.6	96.7	90.0	90.00	100.0	93.3	73.3	83.3
2	Pathik	86.7	93.4	83.3	90.00	80.0	86.7	100.0	96.7
3	Punam	93.3	93.3	90.0	80.0	83.3	100.0	86.7	83.3
4	Hemant	86.7	86.6	90.0	80.0	100.0	83.3	80.0	93.3
5	Sumit	83.3	76.6	93.3	90.0	100.00	70.0	80.0	86.7

Low Achievers

		I	II	III	IV	V	VI	VII	VIII
1	Abhijit	46.7	70.0	63.3	90.0	76.7	56.7	66.7	53.3
2	Sriram	36.7	56.7	43.3	50.0	30.0	60.0	40.0	56.7
3	Nilesh	43.3	66.7	60.0	30.0	43.3	50.0	60.0	73.3
4	Hitesh	36.7	66.7	30.0	30.0	53.3	63.3	46.7	63.3
5	Shreyas	46.7	53.3	53.3	90.0	40.0	56.7	46.7	76.7

Graph No. 10

210

High Achievers

	Anirban
	Pathik
	Punam
	Hemant
	Sumit

SCORES (In percentages)

CRITERION TESTS

Graph No. 11

Low Achievers

211

steady pattern as we cannot expect the scores to be same throughout. Only two times their score has gone below 75% out of a total of 40 (8 x 5) scores, which is commendable.

The low achievers scoring pattern shows definite improvement. Interestingly the score has reached above 75% four times out of which 2 were 90s. The strategy has helped the low achievers to better their performance. The graph No.11 shows how erratic their scoring was. This is only as can be expected; for what steadyness can be had from low performers unless they reach a high level of learning. From level below 50% we see that their performance goes above that. In fact, there were only 14 scores below 50% and the rest 26 scores were above 50% which shows progress. The instructional strategy thus succeeded in accelerating the progress of the low achievers, however small it may be.

5.6.2 Capability Level Analysis

The criterion tests were so designed as to obtain the scores with respect to various capabilities also. This was required because sometimes it may so happen that the instructional strategy adopted may be'

good, say at concept level only. This level-wise
analysis, in fact, tells us, the suitability of the
material developed and instructional events employed
were of great use in the classroom or not, at all levels.
The capabilities identified were as Gagne suggested.

(a) Concept Capability

(b) Rule Capability

(c) Problem Solving Capability

These three capabilities are discussed individually in
the next section. Only the criterion tests scores are
used in the analysis.

(a) <u>Concept Capability</u>

The results shown in table No.12 is the
percentile mean and standard deviation values on
criterion test scores at the concept level for the
experimental group A and control group B. The values at
different levels show that group A always had a better
score than group B. There was not even a single level
where the score was more for group B than for group A.
The P_{90} level for group A, interestingly, varies
between 95.9 and 99.4 as compared to 82 to 92 interval
for group B. For the fifth test the median value

Table No.12 : Percentiles, Mean and Standard Deviation Values on
Criterion Tests

C O N C E P T S

| Topics → | I | | II | | III | | IV | | V | | VI | | VII | | VIII | |
Groups →	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
P_{10}	61.5	53.3	63.3	37.3	66.2	33.3	27.3	6.8	71.4	46.5	53.9	8.5	52.9	42.5	57.5	51.8
P_{20}	66.8	60.1	69.5	43.1	73.9	40.1	41.8	39.5	82.9	55.0	70.9	44.1	58.1	47.4	71.1	62.5
P_{30}	72.3	63.2	72.4	47.9	79.2	46.9	71.7	44.5	85.6	63.5	74.2	51.0	65.8	52.5	76.4	70.8
P_{40}	78.5	66.0	74.8	52.8	83.3	53.7	75.8	48.8	88.2	71.7	77.1	59.5	73.1	58.2	81.2	75.6
P_{50}	83.4	68.8	77.1	57.6	87.0	60.5	79.9	54.5	90.8	78.5	81.0	74.3	78.4	63.8	84.3	81.2
P_{60}	89.4	72.5	79.4	62.5	90.6	64.8	82.8	64.5	92.7	82.7	84.3	78.5	83.6	69.5	87.3	82.8
P_{70}	92.6	77.4	86.8	67.4	93.1	69.0	85.4	75.2	94.7	85.8	87.7	82.0	88.9	81.5	90.4	85.0
P_{80}	95.2	82.2	93.1	73.5	95.6	77.8	88.1	81.0	96.6	88.9	91.3	84.8	93.1	85.8	93.8	87.3
P_{90}	97.9	87.1	96.8	82.0	99.4	87.0	98.3	89.5	98.1	92.0	95.9	87.7	96.8	90.0	97.1	89.6
Mean	85.7	74.4	83.5	62.9	88.9	63.8	74.3	62.9	94.1	77.9	83.0	65.6	80.8	70.3	83.0	77.1
Sample S.D.	14.4	12.4	12.1	15.9	12.0	19.5	24.3	22.4	6.9	17.5	14.7	29.9	16.4	18.5	22.0	22.9

reaches a very high value of 90.8 for group A as
compared to 78.5 for group B. It is at the lowest
percentiles the differences are made very wide. The P_{10}
value, for the 2nd test 63.3 for group A and 37.3 for
group B; 3rd test, 66.2 for group A and 33.3 for group B;
fourth test, 27.3 for group A and 6.8 for group B; fifth
test, 71.4 for group A and 46.5 for group B and the 6th
test, 53.9 for group A and 8.5 for group B are all
indicating an upward shift of the group A scoring pattern
as compared to the low scoring profile of group B.

The arithmetic mean values for various test
showed that in all cases group A was leading group B.
The group A values varied from 74.3 to 94.1 while for
group B it varied from 62.9 to 77.9. The value of 94.1 for
the mean score for the criterion test V of group A is
singularly high performance. The values shows better
capability acquisition by group A than group B. The
group B scoring shows more variation than group A which
is evident from their value for standard deviation.

Graph No.12 represents the mean concept scores
for all the criterion tests. The graph of the concept
scores for group A shows a higher level scoring pattern
as compared to that of group B. There is a sudden dip

Graph No. 12

MEAN CONCEPT SCORES (In percentages)
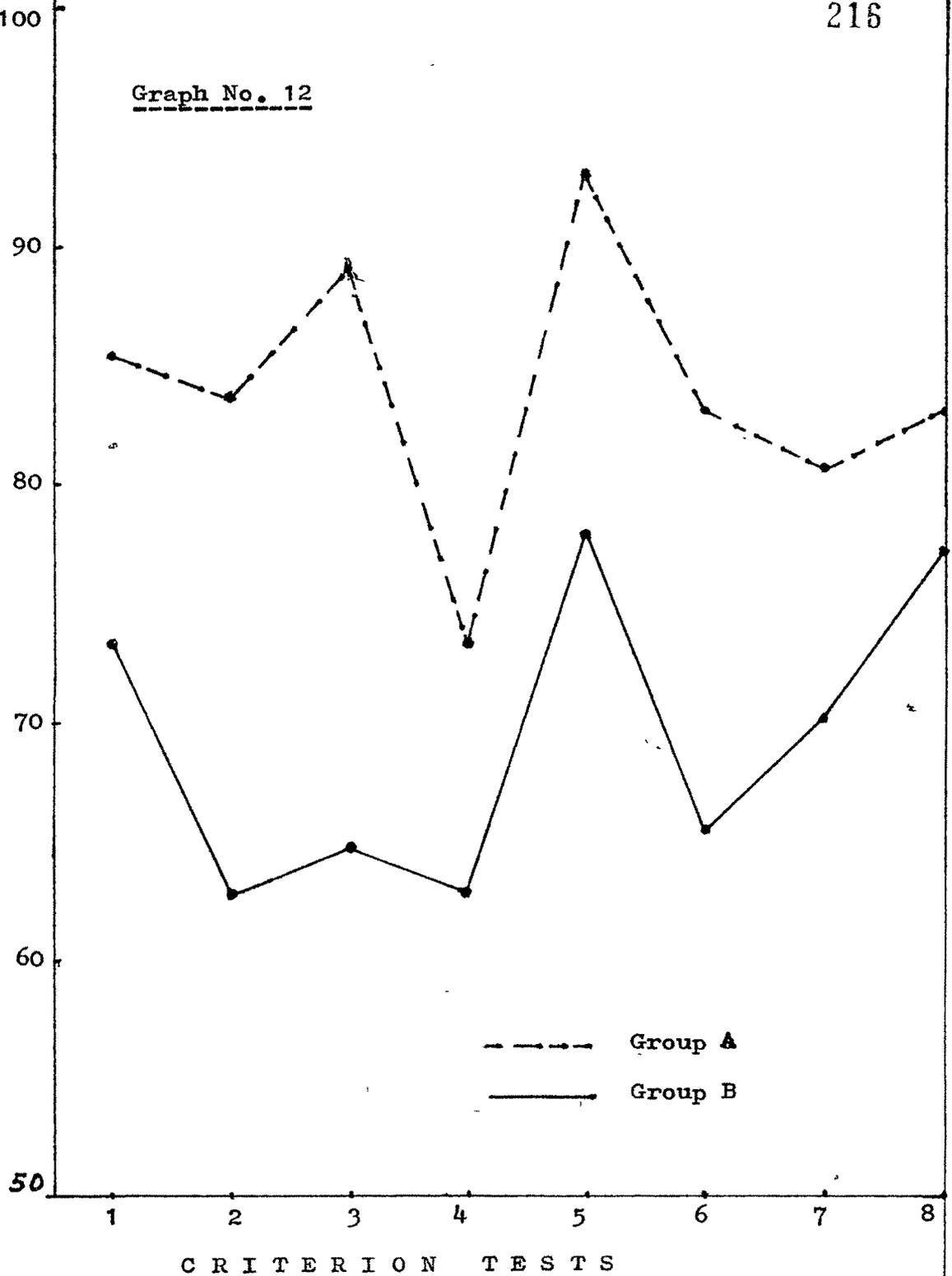
CRITERION TESTS

---- Group A
—— Group B

for the scores for criterion test No.4 which needs

our attention at the feedback session on the topic

Newton's 3rd Law of Motion and equally so sudden use

for test No.4 on the topic conservation of momentum.

Except for the magnitude of variation the group B curve

also shows similar ascends and descends. At no place the

curve overlaps. The group A curve keeps its lead

throughout. The wide gap shown by the graphs for group A

and group B is an indication of the excellent performance

of group A and the usefulness of the instructional

strategy employed. In general, the way the software was

developed about the concept was liked by most students.

The reaction from the students was highly favourable. This

was because most of the attributes which contributes

towards a particular concept was very clearly dealt with.

(b)   Rule Capability

Table No.13 gives the percentile mean and

standard deviation values at rule level on criterion

tests. The percentile values on the first criterion test

showed interesting results. Value for P_{40} , P_{50} , P_{60}

and P_{70} was higher for group B compared to that of group A.

In fact the mean scores for group A and group B were very

close with values 51.6 and 49.4 respectively. At the

Table No.13:   Percentiles, Mean and Standard Deviation
Values on Criterion Tests

R U L E S

Topics→	I A	I B	II A	II B	III A	III B	V A	V B	VI A	VI B	VII A	VII B	VIII A	VIII B
P_{10}	31.0	14.5	26.2	6.8	17.9	11.7	4.11	2.4	49.5	32.5	35.9	16.5	36.2	31.5
P_{20}	33.6	20.2	38.5	13.1	25.3	14.5	8.22	4.9	57.3	45.0	43.3	25.0	46.5	40.0
P_{30}	36.3	35.8	45.6	17.9	33.3	17.3	27.5	-7.3	64.0	52.5	50.8	33.5	54.7	48.5
P_{40}	39.9	50.8	51.0	21.8	43.2	20.2	39.8	9.7	70.2	58.2	70.0	41.7	61.5	62.0
P_{50}	50.9	52.6	53.5	24.7	53.5	24.8	65.5	16.5	74.8	63.8	71.5	48.5	66.1	70.5
P_{60}	53.5	54.4	56.0	27.5	60.8	29.6	86.5	25.2	79.5	69.5	78.9	58.5	72.3	73.9
P_{70}	56.1	56.2	58.4	30.3	66.1	45.2	92.6	48.5	84.1	74.5	86.3	65.2	74.0	77.3
P_{80}	58.8	58.0	72.0	53.6	71.7	50.8	95.2	92.0	88.8	79.4	92.2	71.0	77.4	80.8
P_{90}	73.8	59.8	81.5	58.5	79.1	56.5	97.8	96.3	94.3	85.7	96.3	79.5	82.0	85.6
Mean	51.6	49.4	57.8	33.2	54.9	35.6	58.9	36.5	77.6	65.6	71.9	53.2	66.5	65.6
S.D.	19.1	20.4	19.3	19.8	23.3	18.5	41.4	41.4	16.6	20.9	24.1	23.3	20.6	23.8

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P_{90} level the group A value showed a sudden change with 73.8 as compared to 59.8 of group B. Except for the first criterion test the value for rule capability at various percentile level was higher for group A in relation to group B. The percentile values for rules were very much less than that for the concept level indicating the increase in difficulty level as the test items moved from concept to rules. Test No.3, 4 and 5 shows very low scoring for group B. 10% of the group B students got a score less than 68 for 2nd test, 11.7 for 3rd test and 2.4 for 5th test. In the same tests group B students showed very low results with 5th percentile values 24.7 for 2nd test, 24.8 for 3rd test and 16.5 for 5th test. But the group A values were not much affected for these tests.

The arithmetic mean value for group A scores varied from 51.6 of the first test to 77.6 of the 6th test; while for group B it varied from 33.2 of the 2nd test to 65.6 of 6th and 8th test. The mean value falling below 50% for the first (49.4), the second (33.2), 3rd (35.6) and 5th (36.5) in the case of group B the scoring show a low trend. The best result came from 6th test on gravitation with mean values 77.6 for group A and 65.6 for group B.

Graph No. 13

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MEAN RULE SCORES

CRITERION TESTS
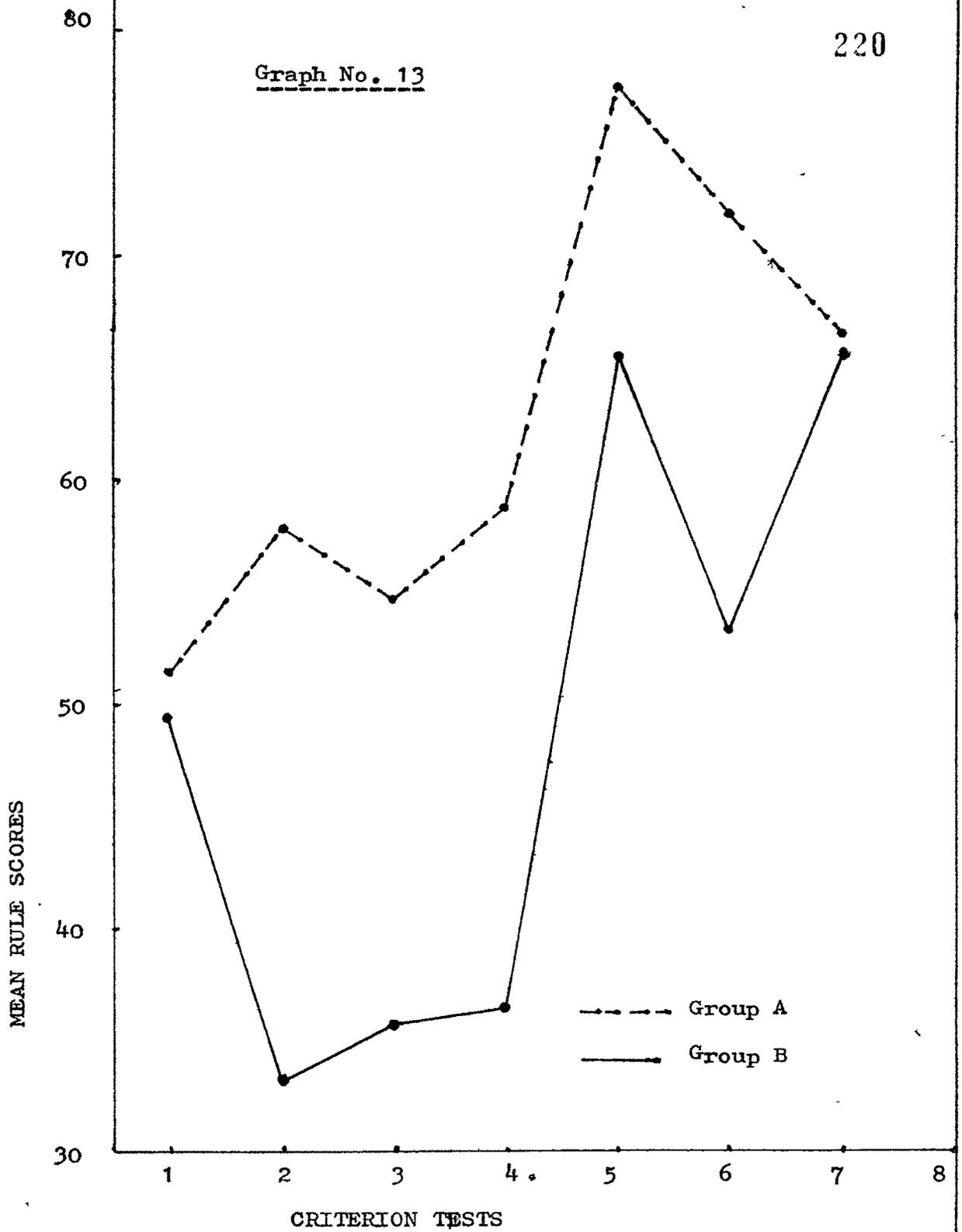
- - - - - Group A
———— Group B

Graph No.13 represents the mean rule score for
group A and group B. The first test values and the last
test values scores to be very close for both the groups.
In between the group B has suddenly dipped while group A
always maintained the progress. Though there is a dip
for group A after 6th test i.e., for 7th and 8th tests
the overall graph shows a general ascend for the graph
showing improving scoring pattern. This is also true for
group B. Not once even the curves overlaps, group A
always keeping the high scoring lead. Thus the graph for
rules also shows that the experimental group had done
better. The dip shown at the 3rd test and 7th and 8th test
indicated the need for a revision at the rule level.

(c) Problem Solving Capability

The percentile, mean, and standard deviation
values for problem solving capability is tabulated in
table No.14. It is in problem solving, group B scores
looked miserably low. At P_{10}, and P_{80}, level in test
No.3, P_{50} level in the 6th test P_{70} level in 7th test group
B values are higher compared to that of group A. All
other percentile values are higher for group A than for
group B. An analysis of the 10th percentile shows some
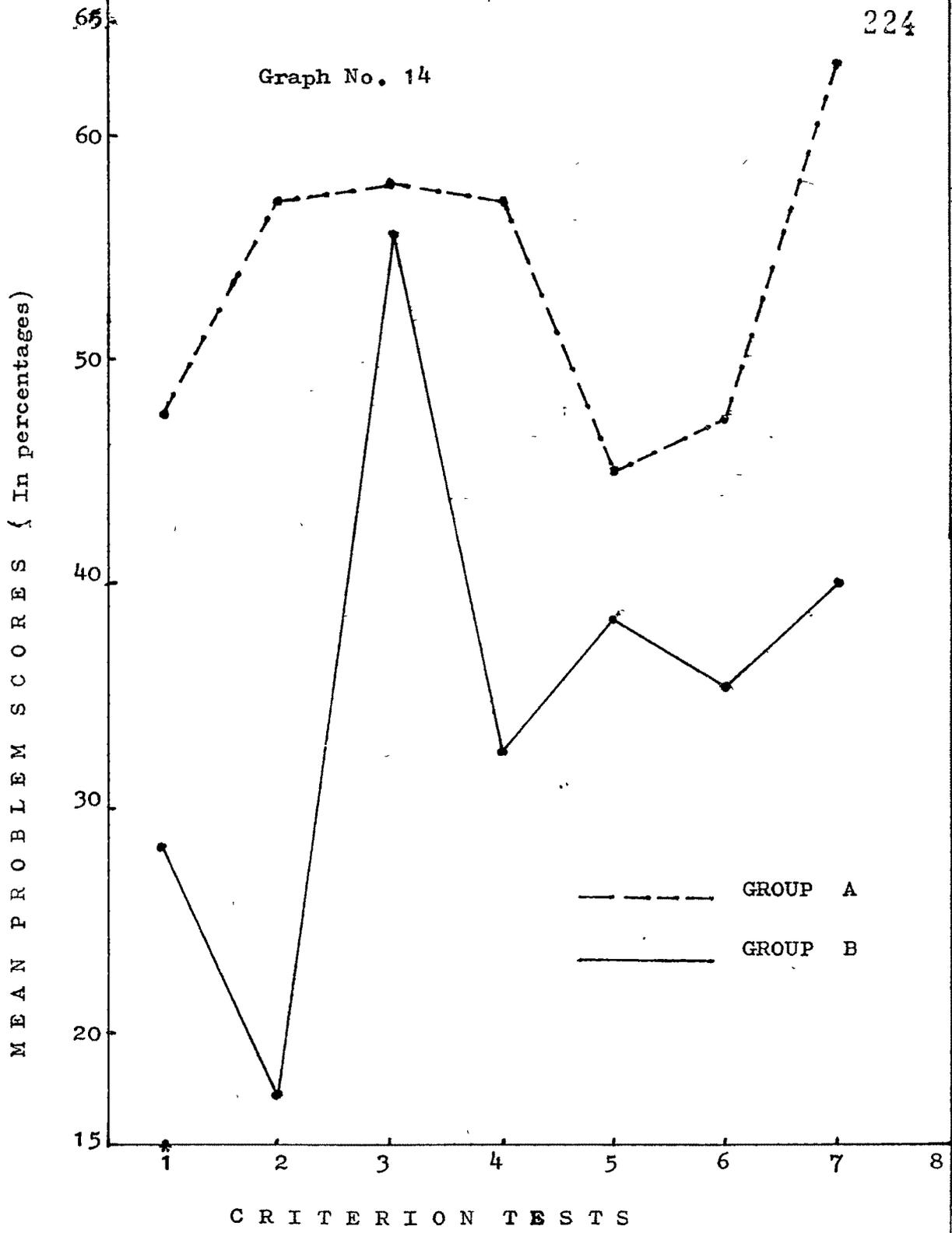very low values for group B with 3.8 for the 1st test,

Table No. 14 :   Percentiles, Mean and Standard Deviation
Values on Criterion Tests

P R O B L E M   S O L V I N G

Topics →	I		II		III		V		VI		VII		VIII	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
P_{10}	14.6	3.8	16.2	1.5	22.8	30.9	22.8	3.1	47.5	12.3	5.3	2.1	32.6	8.5
P_{20}	18.7	7.6	28.5	3.0	35.2	34.0	30.9	6.2	21.6	16.5	12.5	4.3	37.2	17.0
P_{30}	27.5	12.2	34.7	4.4	44.0	37.0	35.1	9.3	24.4	20.8	25.8	6.4	41.7	31.0
P_{40}	33.3	17.1	43.2	5.9	50.2	40.1	39.2	19.2	27.3	25.6	41.5	8.5	45.8	39.5
P_{50}	36.5	22.5	53.5	7.4	61.5	53.8	52.4	24.3	30.1	30.5	46.1	25.5	49.9	42.3
P_{60}	40.9	29.3	61.0	8.9	64.0	59.5	57.0	28.5	46.5	41.2	51.0	37.5	61.1	44.3
P_{70}	48.3	34.0	70.3	18.5	66.4	65.2	65.0	35.0	48.7	46.8	59.8	63.2	73.5	46.3
P_{80}	66.5	38.3	86.5	36.5	68.9	70.8	89.2	51.2	64.5	61.0	78.5	76.5	92.2	48.3
P_{90}	88.2	45.8	95.2	53.5	82.0	76.5	95.2	76.5	82.0	69.5	93.1	89.2	96.5	50.3
Mean	47.6	28.2	57.0	17.1	57.8	55.6	57.0	32.4	45.1	40.9	47.3	35.3	63.2	40.0
Sample S.D.	25.8	20.4	30.7	26.1	24.7	21.3	30.1	30.6	24.9	22.5	34.6	38.9	25.2	21.3

1.5 for the second test, 3.1 for the fifth test and
2.1 for the 8th test. Similarly the median value of
7.4 ┌ for the 2nd test for group B is very low. In fact
group B ┊ had done very badly in the first two tests
at the problem level. The percentile values at various
levels shows high values in favour of group A as compared
to group B. This was on the proper lines as the students
in the experimental group taught through the instructional
strategy which gave a lot of importance to the pre-requisite
capabilities and with greater emphasis on lower order skills
were expected to do better in the higher order skills. If
If we just look at the 90th percentile values obtained we
see that the group A values varies between 82 and 96.5
as compared to the group B values of 45.8 to 89.2 .
Evidently group A had shown their ability to solve
problems.

The arithmetic mean values shown in the table
No.14 clearly indicates that the scoring at the problem
level was less than at the concept or rule level. The
highest mean value attained was only 63.2 for group A in
the 8th test. The lowest value of the mean was 17.1 for
group B in the 2nd test. For test No.3 the mean values
of group A and group B came very close with 57.8 and

Graph No. 14

MEAN PROBLEM SCORES (In percentages)

65

60

50

40

30

20

15

1   2   3   4   5   6   7   8

CRITERION TESTS

— — — — —   GROUP   A

————————   GROUP   B

55.6 respectively. The higher standard deviation values shows that there was more variation at the problem solving level as compared to rule level or concept level. This is only expected as with higher order skills the difficulty level also increases which brings out distinctively the differences among the students.

Graph No.14 represents the mean problem solving scores for various criterion tests. As we see though, there is variation in performance for both the groups; but the variation in the case of group B is more prominant than group B. It is only for the 3rd test group B has done well. The wide gap between the curves exhibits the validity and success of the instructional strategy developed and used in the classroom. The problem solving level --- had reached the lowest bottom for the 6th test and 7th test for group A which may be indicator towards the need for a revision of material at that stage.

Table No.15 gives the percentile, mean and S.D. values on the combined criterion test scores. In fact these values given here, gives a complete picture of the performance of group A and group B. At every level the percentile values of group A was higher than that of

Table No.15:   Percentile Mean and Standard Deviation
Values on Combined Criterion Test Score

	C		R		P	
	A	B	A	B	A	B
P_{10}	71.2	57.3	42.6	32.5	27.3	17.3
P_{20}	75.3	61.7	47.3	37.4	33.9	22.1
P_{30}	79.5	64.0	52.3	41.4	39.2	25.2
P_{40}	82.5	66.2	58.5	44.0	45.1	28.3
P_{50}	85.1	68.5	62.8	46.7	51.3	31.8
P_{60}	87.8	70.9	66.1	49.4	57.5	36.0
P_{70}	90.4	74.0	69.5	52.8	65.3	40.3
P_{80}	93.8	77.0	75.7	57.0	73.7	48.5
P_{90}	97.1	80.1	83.8	63.5	81.3	59.2
Mean	84.5	68.7	62.6	48.3	52.8	35.7
S.D.	9.3	9.1	14.8	12.4	19.6	16.6

group B. Whether it is at the concept level, rule level or problem solving level the group A values are much ahead of group B values.

It is interesting to note that none of the graph discussed so far overlaps and group A curve always leads that of group B. Even the percentile values has beyond doubt established the superiority of group A over group B. All . 'ε indicates the usefulness of the instructional strategy adopted during the study. The graph have very clearly shown, especially that of group B that it is at the problem solving level the instruction needs to give more attention. The variation in the graph definitely indicates the need to give more guided problem solving exercises.

5.6.3 Analysis of Covariance

As mentioned earlier in the beginning of the present study a conscious decision was made not to disturb the sections in the class while naming them as experimental or control group. As such the groups were not matched or rather no effort was made to match the groups, if they were not. In fact no exercise was performed to see whether they were matched. Having said this, as there was

no guarantee that they were matched, natural course
before us was to take them as they were with whatever
differences they may have and to treat them as unlike.
The presence of any difference in the achievement levels
of both the class would have affected the final scores;
thus contributing a source of error in the experiment.
Analysis of covariance was done to remove any such error
in the final values.

In this study, analysis of covariance was done
using the three sets of scores mentioned below :
    (i) combined criterion test score
    (ii) comprehensive test score
    (iii) annual examination score.
In all these analysis the annual examination scores at
the end of Std.VIII were considered as pre-test scores
and as such were taken as constituting the covariate.

The results shown in table No.16 is the summary
of analysis of covariance (ANCOVA) on combined criterion
test scores with previous annual examination score as
covariate in respect of both group A and group B. The F
value of 23.7 is highly significant at .01 level. (The
table values of F .01 = 7.01). (In the table, X is the
uncontrolled variable or covariate). We may conclude,

Table No. 16 :   Analysis of Covariance
Combined Criterion Test Scores

	SOURCE OF VARIANCE		
	Between	Within	Total
Sum of Squares : Y	1898.56	20438.44	22337.00
Sum of Squares : X	4102.88	10367.56	14470.44
Sum of Products	2791.00	11034.44	13325.544
Degrees of Freedom	1.00	69.00	70.00
Adjusted Sum of Squares:X	1503.00	4410.22	5913.21
Degrees of Freedom for Adjusted Sum of Squards	1.00	68.00	69.00
Variance Estimates	1503.00	64.86	

F Value =   23.17

Table No.17 :   Analysis of Covariance
                Comprehensive Test Scores

| | SOURCE OF VARIATION | | |
	Between	Within	Total
Sum of Squares : Y	1898.56	20438.44	22337.00
Sum of Squares : X	3749.75	40738.00	44487.75
Sum of Products	2668.19	24002.06	26570.25
Degrees of Freedom	1.00	69.00	70.00
Adjusted Sum of Squares: X	92.66	12550.97	12643.63
Degrees of Freedom for Adjusted Sum of Squares	1.00	68.00	69.00
Variance Estimates	92.66	184.57	-

F Value =   0.50

Table No. 18 :   Analysis of Covariance
Annual Examination Scores

	SOURCE OF VARIATION		
	Between	Within	Total
Sum of Squares : Y	1898.55	20438.44	22337.00
Sum of Squares : X	1486.81	36055.06	37541.88
Sum of Products	1680.13	22288.38	23968.50
Degrees of Freedom	1.00	69.00	70.00
Adjusted Sum of Squares: X	73.41	11749.31	11322.72
Degrees of Freedom for Adjusted Sum of Squares	1.00	68.00	69.00
Variance Estimates	73.41	172.78	-

F Value = 0.42

score also as a useful parameter. This examination was conducted almost 7 months after our experiment was over. Anyway the ANCOVA did not show any significant result. The F value of 0.42 shows no significance at $P < .01$ or $P < .05$ level.

As a whole we may say that because of the nature of the experiment and the test involved, it is the result of the criterion test which was more valid for discussion which is done in the next section.

5.7   Discussion

Physics in general, is considered to be the most difficult of all sciences; a view held by many learners as well as practioners. This learning difficulty can be overcome by the proper organisation of the learning material. In the present experiment learners were not forced to master the lower skills. They were only asked to do so. The experiment was carried out in a more free atmosphere. The internalisation of new facts, concepts principles was more frequently achieved by direct instruction rather than by the cognitive restructuring process favoured by Piaget (1964) and Brunner (1966) (Hacker, 1984). Gagne's approach makes an attempt in this direction where direct instruction is made to influence the learning process.

By providing support for the learning of
intellectual skills the present research has also
demonstrated the application of learning hierarchy idea
in physics, learning in the actual classroom situation.
Normally these type of learning programmes consumes lot
of time and many successes have been demonstrated at the
expense of long time duration. This long time exposure
for short amount of learning causes problems in the
classroom situations. Hence many experiments die with its
completion itself. Practioners are not in a position to
pick up what the researchers have to say. The researcher
in this study, being a practioner himself, r. given lot of
importance the factor that strategy evolved and the material
developed should be used in actual classroom instruction
even after the present experiment is over. In fact, the
experimental result should boost the use of hierarchy ideas
in the teaching learning process. To what extend is our
research agenda - our questions and answers - linked to
the real world of the science teacher? Have we become so
engrossed in our research that we find only that, for which
we are looking for? These are some of the questions
David P. Butts (1984) asks the researchers. In the present
study an all out effort is made to experiment a strategy

which can later be of immense use to the practioners
and to help them to professionalise instruction.

Increasing the problem solving abilities of
students continues to be a major goal of science teachers.
However students (and thus teachers) continue to be
criticized for their lack of problem solving proficiency.
For a student who is introduced to science discipline the
successful solution of what may appear to be a very simple
and routine problem requires a great deal of knowledge.
Procedural knowledge of how to execute a problem solution
and the knowledge of various concepts and rules which
provide meaning or context to the procedures are both
necessary for a solution to a problem. Science teachers
should be interested in both. A seemingly simple problem
also requires an extensive amount of pre-requisite
capabilities, then it can be argued that there are many
places where a student can go wrong. To simply know
that a student has obtained a wrong (or correct) answers
is not necessarily informative. Their capabilities at
various levels (concepts or rules) should be known to do
anything useful. With such information gathered from many
students it should be possible to make substantive
suggestions for alteration of instruction in a science
discipline.

The present study has clearly shown that
problem solving continues to be the difficult area,
whether it be routine, extension or novel type, for the
students. In fact, as the students approaching problem
solving stages, many of them, especially in the control
group, lacked the ability to integrate the lower order
skills in concepts and rules to interpret and solve the
problem. To most of these weak students the problem
solving poses a much greater difficulty than that in the
other two taken together. We also see that the gap
between group A and group B widened at the problem solving
level. Though this indirectly tells the success of the
strategy adopted at the problem solving level, it also
draws our attention on the need for a broader more
holistic approach to problem-solving instruction. This,
however places a number of responsibilities on the teacher.
The teacher must possess the ability and will to
demonstrate and/or guide students towards solutions.
The problem presented should be also meaningful in the
contexts and to the students and worthy of the effort
expended in finding a solution. The teacher should
encourage the students to support and explain the
rationale behind their solutions as there is a distinct
possibility of many students using trial and error
method which, they must be persuaded to avoid.

The criterion test values have exhibited the usefulness of the material developed. In fact, hierarchy learning, sets the tone of learning of the students as they concentrate only on the required intellectual skills. They need not waste time on unnecessary learning in a haphazard situation. In this process of highly organized learning the learners same time is to be utilized for purposeful learning.

Though the comprehensive test results and annual examination result do not show significant effect, it need not be considered with great importance as the situation in which they were administered were not the same as that for criterion tests and were not the ideal situations created for this type of study.

This study has important implications for the design of instructional materials for secondary school science where the material to be learned contains intellectual skills. There is now quite impressive amount of evidence that these skills should be ordered into a hierarchical sequence for most efficient learning. That is, the pattern of pre-requisite of the terminal skills to be learned should be first established. Further in

situations where the students came to a new course
defficient in certain skills needed to begin the course,
learning hierarchy materials can be used to identify
these missing skills and to guide teaching of them.

The general discussion at the end of the
programme revealed that the students preferred the
learning material developed. The great demand from
group B for the learning material also indicated their
liking of the material developed.

5.8   Conclusion

Providing quality information to teachers and
administrators about learning skills, preferences,
strengths and weaknesses of individual learners is a
challenging task. Developing a good productive
instructional strategy within the parameters of actual
classroom situation is yet another and still more
difficult task to attempt. In both these the instructional
strategy designed and the experiment conducted thereof
has done well. The analysis showed the success of the
strategy though it also indicated the need for some
modifications in the learning material developed. It
also brought out the need for including more extensive
exercises at the problem solving level.

The main findings of the study can be listed as follows :

(i) In the hierarchy of learning problem solving formed the most difficult and weak area for students.

(ii) The learning material developed needed some slight modifications especially regarding the inputs related to problem solving by way of adding more guided problem solving exercises.

(iii) As the students proceeded from concept level to problem level the gap between the experimental group and control group widened as indicated by their performances on criterion tests.

(iv) The instructional strategy was found effective at all three levels as revealed by criterion test scores at concept, rule and problem solving levels. The experiment could not conclude that the strategy had any differential effect on any one of the areas mentioned above.

(v) The analysis did not show that any one
particular group, high achievers or low
achievers, was more benefitted than the other.
The high achievers maintained their mastery
level from the first to last criterion test.
The low achievers had shown a steady
improvement as they moved from first to
the eighth criterion test.

(vi) The instructional strategy as a whole was
found to be more effective than the
traditional method followed in classrooms,
for teaching science.