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ABSTRACT

As preliminary steps in a larger study of how students learn mathematics, two pilot studies were made of the relation between study behavior and achievement. An analysis of the literature showed a lack of descriptive studies including both the study habits and the amount of study time. Forty-six first-year mathematics students were interviewed during the year and just after the examination; results strongly suggested that the distribution and amount of study time is a factor of considerable importance in mathematics achievement. As a general conclusion it was hypothesized that earlier studies failed to show any consistent relationship between study behavior and achievement because measures of the amount and distribution of the number of hours of studying invested by the students were not included. (Author/DT)

Report from the Danish Institute for Educational Research

Sten C. Poulsen

STUDY SKILLS AND MATHEMATICS ACHIEVEMENT.

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STUDY SKILLS AND MATEMATICS ACHIEVEMENT

CONTENT

Copenhagen
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SUMMARY

As preliminary steps in a larger study of how students learn mathematics, two pilot studies were made of the relation between study-behavior and achievement.

An analysis of the literature showed a lack of descriptive studies including both the study-habits and the amount of study-time.

To gain information about the importance of the amount of time invested by the students, 46 first-year mathematics-students were interviewed during the year and just after the examination. The results strongly suggest that the distribution and amount of study-time is a factor of considerable importance for the achievement.

As a general conclusion it is therefore hypothesized, that earlier studies failed to show any consistent relationship between study behavior and achievement because they didn't include measures of the amount and distribution of the number of hours of studying invested by the students.

INTRODUCTION

Background

The initative for this study originally came from a group of student-instructors at the Mathematics Department of the University of Copenhagen. The author for some time had worked in the area of study-skills in mathematics and therefore accepted to conduct a pilot-study.

Research perspective

It is the intention on the basis of studies of literature and empirical research to develop study-skills especially suited for the study of higher mathematics.

SURVEY OF RELATED LITERATURE

Purpose of pilot-study

The pilot-study lasted from January, 1966, until January, 1968. Its purpose was to examine whether any systematic relationship could be ascertained to exist between study-skills and examination marks gained after one year's study of pure mathematics at a university.

Scope of the survey of literature

Surveyed were "Psychological Abstracts" from 1927-1968, "Education Index" from 1957 to 1968, "British Education Index" from 1955 to 1968 as well as Danish, Norwegian, and Swedish national bibliographies from 1957-1968. All articles and books listed under the key-words "study-skills".

"Study-methods" and "study-habits" were surveyed. All reports dealing with study-skills were carefully examined.

Results from the survey of the literature

Most of the literature concerned was found to be dealing with one of the following topics:

1) Handbooks on efficient study-habits
2) Effects of how-to-study courses
3) Relationship between scores on how-to-study questionnaires and some other test-score, i.e. I.Q., examination marks, intelligence, personality characteristics, etc.

Descriptive studies

The important fact is that out of the total 200 entries examined only 5 had reference to studies dealing with the way students actually behave during a longer period.

Studies of the students' actual behaviour over a longer period are important for several reasons. Firstly, they provide a very sound method of discovering efficient study techniques. A comparison of study behaviour and marks gained at examinations makes it possible to form an idea of which study-habits are the most efficient. No doubt, it is desirable to control I.Q. and other factors too, but in so far as the intention is primarily to obtain some suggestions of efficient habits, such control can well be dispensed with. Secondly, they are absolutely necessary in order to develop valid instruments by means of which study-behaviour of

students can be described. Instruments of this kind are indispensable when it is desired to ascertain whether the student's study behaviour has actually been influenced by his taking part in a how-to-study course, or when it is desired to compare study-behaviour with some other factors. It might bee expected, therefore, that studies of this kind were in the majority. However, the surprising fact is that this is not the case. This being so, one might well ask where the advice given in how-to-study courses come from. The answer seems to be that it comes from handbooks giving how-to-study techniques, and not from research.

How-to-study handbooks

An analysis of the contents of handbooks will reveal that a substantial part of it is based upon the personal experience of the writer himself or other writers. A source of this kind is not necessarily a bad one, but it is generally impossible to know whether the experience described is merely idiosyncratic, or is in the nature of general advice for anyone to benefit from.

The rest of the contents mainly consists of generalizations of results from human - and even animal - learning experiments. In most cases, they are experiments concerning a very limited learning problem, and conducted under laboratory conditions. Hardly ever is any evidence provided to support the validity of the assertions, which are generally

nothing but far-fetched generalizations.

An infinitisimal part of the contents is based upon a study of the students' actual behaviour, and what studies have actually been carried out, are genereally so limited in scope as to make it impossible to accept their findings as being of such general validity as the handbooks purport.

Existing instruments

A few instruments known internationally, it is true, exist already. The one most widely used is perhaps the Brown-Holzman Study Habits inventory, which must be based upon a study of the kind required above, but nowhere has any detailed description been given of such a study.

Attempts to compare scores on the mentioned inventory with examination marks have not met with unqualified success.

The reason may after the conclusion of this pilot-study be said to be rather obvious. It was found -- contrary to results of other studies undertaken - that there was a positive relationship between the total number of hours spent during one year and the achievement. (Differences in environments may explain this difference between university and school). Further the time spent in direct preparation for the examination could constitute up to 50 per cent of the time used on homework during the year.

If these findings are correct, the practical consequences must be:- 1) that a study-habit in-

ventory unless it includes questions for detailed information on the number of hours invested, cannot be expected to disclose the importance of the total study behaviour, and 2) that even if such questions are included, the relationship of investment of time and method of study to examination marks will still remain unclear unless provision is made for time spent in direct preparation for an examination.

It is surprising that the time-variable has been so neglected. It may be due to the fact that the studies undertaken of school children have been unable to reveal any close relationship between study-time and examination marks.

Conclusion

The conclusion after the survey of the literature was that descriptive studies of actual study-behaviour during a longer period was urgently needed.

ANALYSIS OF SELECTED LITERATURE

The selected studies

Of the 200 studies surveyed only five included attempts at attaining some kind of description of students' actual study practices.

Gibbons & Savage, 1965

The study is based on tests and correlation coefficients. It has been included only because of the positive correlation of 0.37 found by the authors to exist between the number of home-study hours and examination results gained at the end of the year.

Maddox, 1963

The advice found in study-skills manuals often seems farfetched to the sceptical mind. For this reason, Maddox compared the advised distribution of home-study-time - and recitation - with the actual study habits of 64 university students.

Not surprisingly, he found that these students did not at all study as the manuals advised.

However, his failure to compare his results with the students' examination marks, makes it impossible for us to form an opinion as to whether the advices are effectual or not.

Malleson, 1960

Using questionnaires and forced choice, Malleson found no positive correlation between home-study-time and achievement. However, he did not ask about time spent in direct preparation for the examination. Besides, there are some gaps in his material.

Thoday, 1957 and van Paarreren, 1964

The two remaining studies are outstanding in the quality of procedure adopted. The results bear directly on the problem posed in the pilot-study.

Doris Thoday used a thoroughly tested interview form to decide among other things how much time the students spent on home-work. Especially, the description of the procedure is unusually detailed and of great interest. The author found a positive relation between the number of hours of home study and the achievement (examination marks),

but fails to present any figures regarding this single issue. Sex-differences were not found to be of any importance. The number of subjects were 503 (370 male and 133 female students).

Van Paarreren and Schutte-Poen in 1964 reported another thorough investigation using carefully prepared interview-forms.

The purpose was to describe the actual study-behaviour of successful and unsuccessful psychology students.

Unfortunately, questions about home-study hours were not included, but some other interesting findings emerged:- Those who succeeded studied with more purpose, worked alone, attached great importance to knowing details of the demands at the examination, and showed more self-criticism as well as independence.

Summary

It is interesting to note that those of the results that emerged affiliated to this pilot-study, entirely supported the conclusions of the latter.

The survey of literature and the analysis of selected studies showed two other general tendencies viz.- 1) that the method of tests, questionnaires, and inventories is currently being abandoned in favour of that of personal interviews based on carefully pretested interview-forms, and 2) that increasing emphasis is being put on the number of home-study hours, a factor of substantial importance.

EMPIRICAL RESEARCH

It is important to note that the pilot-study was not an experiment nor an hypothesis confirming study.

Its purpose was only to describe how the students actually studied, how much time they spent on their studies - and to analyze the relationship of these traits of behaviour to the examination marks at the end of the year.

This purpose as well as the design of the pilot-study precludes any possibility of drawing conclusions as to cause-effect relationships. It can here be disclosed that numerous systematic relationships were found. Many of these give reason to believe that the behaviour-traits in question were real and important causal factors behind the achievement, but the research design does not allow any definite conclusions of this kind.

The present study might for short be classified as a variable-finding one. Several study-behaviour-variables have, in fact, been pinpointed, but whether they really are important causal factors only further studies can show.

The setting of the pilot study

The study of pure mathematics lasts from five to seven years at the University of Copenhagen. In the course of this study the student must pass a number of important examinations one of the most decisive of which is at the end of his first year of study since

it acts as an efficient limiting gate, reducing the number of students by 80-90 per cent.

It is important to note that the program of study is of a very free nature. During the first year there are 22 weekly classes at the university; 14 lectures and 8 hours for solving mathematical problems (exercises). The students are free to attend or do their study at home. They can theoretically remain at home all the year and still be permitted to the examinations.

The student population

The students when they begin their first year of university study, come directly from the Gymnasium which they have finished at the average age of 18-19. Some may have spent an intermittant year before making their final decisions as to study, they may have tried other subjects, too, and others may have failed at the previous examination in June and are now trying again. It must be noticed that they come from a Gymnasium where everything is prearranged, and where their work is constantly supervised and controlled, to a university program where nobody cares about them at all, and where their study-behaviour however efficient it may have proved to be at the Gymnasium cannot help them any longer.

Selection of subjects

Out of the total number of first-year university students was selected a group of 50 all coming directly from the Gymnasium without delay. The group comprised 18 female and 32 male students, all being from 18 to 20 years old.

Selection of method

The studies surveyed had failed to show any clear and definite relationship between study-behaviour and school achievement. This might support the assumption that no such relationship does in fact exist, but it might on the other hand merely reflect the inadequacy of the research method adopted, i.e. inventories and questionnaires. Perhaps a mere thorough investigation based upon personal interviews including both open and more closed questions would give different results?

The method of personal interviews was decided upon. Further, it was decided to make careful observations of how the method worked, what kind of methodological difficulties would be met with and how these could best be solved. Finally, it was decided to give much attention to the construction of the interviewform and ample time for the contacting and interviewing of all the subjects selected.

The total design of the pilot study

In the spring of 1966 older students were contacted personally. They agreed to give ideas as to important and relevant questions concerning the study-behaviour in the first year at the university. On the basis of their information and ideas from handbooks on how-to-study the first draft interviewform was made. It was used in interviews of other older students and then revised. In December 1966 - January 1967 one fifth of the subjects were interviewed according to the revised draft, after which the final revision was made. By constructing the interview-form in this manner it was hoped to ensure maximum relevancy and easy of communication. The latter was fully attained. The students were surprised that the questions touched on so many important aspects, and that the interviewer (then a graduate student of psychology) knew so much of their problems although he knew nothing of mathematics himself.

The two interview forms

The A-form concentrated on the study behaviour during the year before the preparation for the examination started. It contained 124 open and closed questions about their study behaviour, their final examination marks in the Gymnasium, how much average time they spent per week on study, shorter or longer pauses during the year, their reasons for choosing pure mathematics, reasons for dropping out, etc. It took about 45 minutes to go through.

The B-form concentrated on the preparation for the examination, how much time was spent before the first part of the three parts of the examination and between these parts, whether they primarily concentrated on theory or the solving of problems, how they prepared themselves for the oral part and how for the written part of the examination. It contained 52 questions and took about 25 minutes to go through.

The total design

The fifty students began at the university on the 1st September, 1966. In March and April, 1967, 46 were interviewed singly according to the A-form. The remaining 4, unfortunately, were never interviewed. Of the 46 students 20 attended the examination, and only 5 passed.(These 20 were all interviewed just after the examination according to the B-form.) 10 had dropped out, and 16 had decided to present themselves for examination six months later in January, 1968.

During the interviews the interviewer tried to obtain a maximum of mutual rapport. He changed his way of posing questions watching his facial and bodily expressions so that the subject would be under the impression that he could tell everything about his actual study behaviour without being an any way distrusted or ridiculed by the interviewer. It was the interviewer's subjective impression that this informal atmosphere was definitely created in almost all interviews. At least, none of the interviews was cut short by the student before finishing.

RESULTS AND CONCLUSION

It is the author's opinion that one important reason for earlier failures to describe effective study habits has been an excessive eagerness to quantify the raw answers at much to early a stage.

Consequently, in this pilot-study none of the answers was evaluated by any score or in any way transformed into numerical values. The raw answers were simply counted, no attempt being made at any forced classification of the answers into categories.

The author distrusts the value of correlation coefficients and statistical measures of various kinds. It was decided to make simple two-dimensional figures showing the real distribution of some characteristics according to the results of the year's work, i.e.: 1) dropping out 2) postponing examination until next January 3) failing in the examination and 4) passing the examination. 3) and 4) were graduated according to examination marks.

In this way 200 diagrams were drawn up directly illustrating the distribution. Only the averages of the four groups were computed.

Number of subjects

Quite a few critics have noted the relative small sizes of the four groups of students (10, 16, 15, and 5 subjects). Two factors should be taken into consideration, however:- 1) It was in part for this very reason that all sophisticated statistical techniques were dispensed with. The actual distributions are clear for anyone to see. 2) If it is endeavoured to demonstrate the existence of scientific laws appertaining to a certain population, then these laws must appertain to any member of the group, and will be capable of easy observation however small the number of subjects.

In the following stages of this project the groups of persons examined will not be larger than 30-40. If the relationships looked for cannot be shown to appertain to this number of subjects, they cannot be expected to appertain to a larger population.

Results

It is difficult to describe the complete range of the results. Many traits showed a systematic relationship to the examination marks. Unfortunately, owing to the simple research design, it is not possible 1) to take this as proof of their casual influence, nor 2) to evaluate the possible relative effects of the single traits.

Important traits (see appendix on page 21, 22 and 23)

The students obtaining the highest marks differed from the rest in four respects:- 1) They used considerably more time on study activities than did the others, (see appendix page 21, 22 and 23), 2) their time-investment was very evenly distributed, i.e. they did everything they could to avoid weak points in their grasp of the subject. 3) They allocated relatively more time to the study of the theory than to the solving of problems as compared with the other students. So when they began solving the problems they were thoroughly familiar already with the theory. 4) They made sure by active recitation in most cases written that they could, in fact, not only follow the argumentation in their books, but also without any help from others write down the proofs and give reasons for every important step in them. This seemed to be the trait marking them out most sharply from the rest of the subjects. 5) In contrast to the other subjects they attended all lectures, all exercises, and solved more problems than any other group.

It is important notice that these four traits were all present where high marks were obtained. The total of the four traits appear to be necessary, because, students who only just failed evinced most of the traits, but lacked one or two of them.

Sex differences

No sex differences with regard to study habits at all were found.

Other interesting findings

The students were asked to list factors which in their opinion might have influenced their achievement. Not one of the 46 students mentioned their study-habits as a possibly contributing factor of importance.

The interview according to the B-form showed that only the succesful students undertook to make, as part of the learning process, an active recitation of the proofs before the oral examination and of the theorems and definitions before the written examination.

Those who succeeded had obtained very high marks in the Gymnasium. However, 75 per cent of all who had obtained these high marks failed in the examination. It is of great interest to note, also, that taken as a group those who in the Gymnasium had obtained the highest marks, invested much more time in their study activities than the other students.

Further, the B-form disclosed, as already said, that the time spent during the preparation for the examination constituted up to 50 per cent of the total number of hours spent on homework during the previous nine months. The importance of this is obvious if one wishes to predict the achievement of a student: even comprehensive tests on study-skills including time spent on homework cannot be expected to be reliable predictors, since the final preparation seems in itself to be a very decisive factor,

On the basis of the answers concerning study-behaviour it was possible to make a detailed longitudinal description of selected students' behaviour during the ten months of study. The descriptions proved very illuminating as to possible factors behind the study achievement. The descriptions and a careful analysis of the rest of the answers make the main conclusion justified: Under the described circumstances and with the described population the achievements in mathematics after ten months of study is systematically related to quite a number of traits in the study behaviour. Or, in other words, there is in the material no justification for the view that one single aspect of the study behaviour is of decisive importance. It is true that almost all the successful students showed the five abovementioned traits, but none of the traits seemed to outrank the others in importance, and - what is even more important - the unsuccesful students' study behaviour seemed to show very many traits that had a negative influence. The practical consequence of this conclusion is evident and support existing how-to-study courses: Any advice as to study-habits must be thoroughly individualized and calculated to assist the student on a great many points.

Evaluation of the method

The focus of this pilot project was the students' actual study-behaviour during their ten months of study.

There was, however, another purpose:- to asses the usefulness of the method of personal interviews with respect to this problem.

The assets of the method were several:-

1) It is possible to get a complete set of answers from homogeneous, well-defined groups if the interviewer really invests time and money in contacting the subjects: Only one out of 50 students flatly denied to perticipate. Three others who were

not interviewed could have been contacted if the interviewer had had a little more time and money. Of these three two later confirmed that they would gladly have participated.

2) A thorough pre-tesing of early drafts of the interview-form makes it possible to cover the most important aspects of the subject and to facilitate communication by using the subjects' own idiom and expressions.

3) The data-gathering is very flexible: The interviewer can ask any additional questions that come to his mind and can check back on other subjects if it seems useful.

4) If the interviewer has pretested the interviewform carefully and takes pains to understand and accept the subjects' comments and answers, he will get information even on aspects which are painful for the subjects to realize, i.e. negative and inefficient aspects of their study behaviour.

5) Finally, the method is rather inexpensive as compared with laboratory set-ups or direct observation.

The basic weakness of the method

The single most important weakness of the method - the one that gives it a rather dubious value if used exclusively - is, of course, the validity of the answers. Only in a very few cases can the truthfulness of the answers be checked, so in almost all questions concerning study-behaviour the answers given have had to be accepted without any knowledge as to whether they gave a true and adequate picture of their actual study-behaviour.

Conclusion

The conclusions drawn as to the value of the method adopted is that it can be used for pilot-studies or in connection with other methods with greater validity-value, but that it cannot be used as a

sole instrument if it is desired to know - once and for all - how students actually behave while engaging in study activities. It might, by way of a small digression, be noted that none of the broad open questions about how the students did this or that gave any interesting answers. Only the well-prepared precise questions about micro-processes in their homework gave useful information and furthermore provoked thoughtful comments from the subjects. Without the careful and time-consuming pre-tests these detailed questions could not have been formulated.

Evaluation of the results

It follows from this conclusion that however satisfactory the answers may seem, reservations must be made as to their truthfulness and complete validity. Therefore, this method will not be employed without additional checks in the next phases of this project.

It would have been very interesting to compare the study-behaviour and the examination marks with the IQ of the subjects. It is a pity that such comparison is not available. It is due to two considerations:-

1) many subjects would presumably decline this request (Danish students are not all used to frequent testing)

2) the director of the pilot-study simply had insufficient time and funds to do it.

THE NEXT PHASES OF THE PROJECT

Sideline of the project

The professors and teachers in the Mathematics Department showed a great interest in the results and asked for a concentrated how-to-study guide for the new students. This was done, and in September, 1968, about 500 students received a twenty-page pamphlet advising them on how to study mathematics at the university. In the spring of 1969 this how-to-study

guide was thoroughly revised and up-dated, and was in the fall of 1969 again distributed to the students.1)

In the summer of 1969 a follow-up study was made on the 46 mathematics students who had participated in the pilot-study 1966-1967. The purpose was to find out what they were doing three years after enrolment at the university and what they now thought about their first year as mathematics-students. In brief the findings were, that half of them had changed to other subjects where they generally did well. A clear majority was dissatisfied with the relevance and truthfulness of the information they had received in the gymnasium about the university. They wanted a more realistic counseling on this point coupled with regular visits to the university in the last year of the gymnasium.2)

In the coming phases of the project, information will be sought obtained on the problem on making subjects verbalize, i.e. think aloud, while reading mathematics textbooks and solving problem. If this seems possible the studies will gradually be enlarged and include ITV-recording, thinking aloud, stimulated recall and intensive interviews in order to get a detailed understanding of how students behave and what they think while learning mathematics. At present however an effort is made to find research literature concerned with the subject, so far with very limited succes. If the reader knows of any studies which might be relevant he is kindly asked to send a brief note about it to the institute.

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1) See p. 2o: Poulsen, S.C., 1969.

2) See p. 2o: Poulsen, S.C., 197o.

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APPENDIX

Table 1: Number of hours spent on homework until the beginning of the preparation for the examination:-

Passed the examination:	470	
Failed the examination:	590	1/9/1966 until 1/5/1967
Postponed the examination:	235	

Table 2: Number of hours spent on homework until the last day of the examination:-

Passed the examination:	680	
Failed the examination:	620	1/9/1966 until 26/6/1967

Table 3: Part of study time allocated study of theory and problem solving respectively:-

	Theory	Problem solving
Passed	66%	34%
Failed	45%	54%
Postponed	43%	57%
Dropped out	48%	52%

Table 4: Attendance at lectures and exercises:-

	Lectures	Exercises
Passed	100%	100%
Failed	92%	85%
Postponed	58%	40%
Dropped out	81%	[illegible]%

Table 5: How often was theory studied before lectures?

Passed	52%
Failed	23%
Postponed	22%
Dropped out	35%

Table 6: Number of problem. solved during the year:-

Passed	65%	percentage out of the total number of problems set
Failed	50%	
Postponed	33%	
Dropped out	36%	

Table 7: Number of days when the students relaxed and did not study at all:- (not including sundays and holidays).

Passed	4 days
Failed	18 days
Postponed	35 days
Dropped out	12 days

An analysis of the time invested in home-study

If we look at the number of hours studied by the respective groups of students who a) passed, b) failed, or c) postponed the examination, we find the following interesting relationships:-

Those who postponed studied much less than the other two groups during the period 1/9/1966 - 1/5/1967, viz.- 235 hours. During the same period those who failed, had put in a total of 590 hours and the successful students 470 hours of study.

During the period 1/5/1967 - 26/6/1967, i.e. the time reserved for reading-up in preparation for the three-part examination, those who failed put in a total of 30 hours while the successful students put in 210 hours. All figures given are average. The low average of those who failed, is due to the fact that many of them gave up very soon after the 1/5/1967 without going through all of the three parts of the examination. The conclusion to be drawn is clear:- The successful students had sufficient energy and stamina left so as to put in, during the last and decisive two months of the term, upwards of 50% of their total time investment in the previous eight months. Their level of intelligence, no doubt, played a large part in their success, but the remarkable thing is that in contrast to their previously more industrious co-students who had by then exhausted their resources, the successful students' capacity for work was in full bloom. By the final day of the examination they had put in a total of 680 hours of home study during the ten months taken as a whole, while the unsuccessful averaged 60 hours less finishing with a total input of 620 hours. Since the figures are average ones, some allowance must be made for overlapping in the distribution. With this reservation in mind, it seems fully justifiable to draw the conclusion drawn from the actual distribution figures.

It might be advisable, so it seems, to work at a rate less than full capacity during the year, provided, however, that resources are stored up sufficiently in the process for the real effort to be made in the last

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