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ABSTRACT

This three-part paper describes the development of a software program called "The Growth Curve of Microorganisms" for a tenth-grade biology class. Designed to improve students' cognitive skills, the program enables them to investigate, through computer simulations, the impact upon the growth curve of a population of three variables: temperature, nutrient concentrations, and initial cell numbers. In presenting the sequence of the developmental steps, the first section of this report examines the basic assumptions of using computer-assisted learning (CAL) in the classroom and the criteria for efficiency, the formation of a team of developers, and how the team works. The description of the program in the second section includes the rationale for using the microcomputers and its integration into learning activities in the classroom and the laboratory, the four steps covered by the computer simulations, and the procedures for a self-assessment test. The third section discusses three factors involved in the implementation process: classroom setting, the student and self-paced progress, and the role of the teacher in the classroom. Four flow charts are provided which depict the modular course, steps of the development team stage, student self-paced activities, and classroom management activities. (DJR)

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A CASE STUDY OF A COMPUTER ASSISSTED LEARNING UNIT "THE GROVTH CURVE OF MICROORGANISMS" DEVELOPMENT, IMPLEMENTATION AND EVALUATION.

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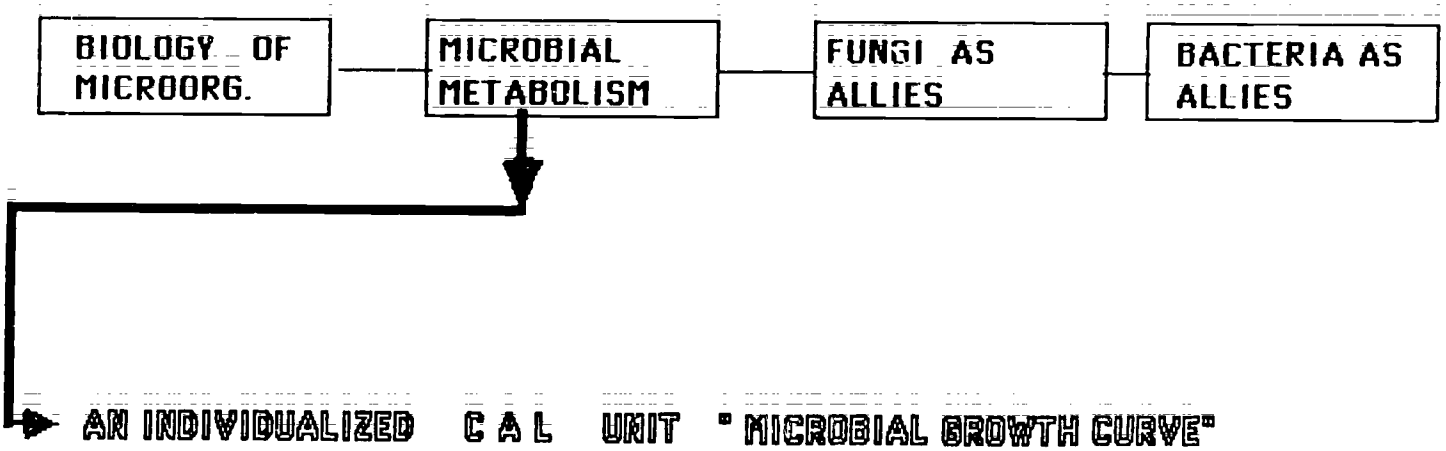
The microcomputer is used in courses for content instruction in different forms such as for test reading, simulations, games, tutorial, drill and practice. While in the U.S.A. it is known as computer assisted instruction (CAI) in England and other countries it is known as computer assisted learning (CAL). In both cases the use of the microcomputer gives us the opportunity of involving the learner actively in the learning process. Since its use is on an individual basis, it can allow students to progress at their own pace, thus having an important implication for the gifted learner as well as for the slow one. The advantages and disadvantages of CAI are mentioned by Chambers and Sprecher (1980); Long term experiments which require expensive equipment and materials can be simulated; the use of microcomputer enables remedial education, development of students' creative abilities so changes are to be expected in the classroom learning environment. As for the disadvantages of using CAI: Teachers and teachers' trainers need to adapt to new methods of working. They may not yet have the necessary expertise in using the microcomputer, a fact which may arouse fears and antipathy. The cost of the equipment; the available software which many times is not adequate according to the content and the methodology used. Bork (1984) described several factors which characterize poor software such as the inadequate use of the interactive and individualizing capabilities of the microcomputer, use of multiple choice items as weak interactive forms, text presentation, and use of pictures and materials of little educational objective purposes. Spain (1985) explains that there are two methods of preparing software. The first approach is this of the persons, who are very few but experts in the subject matter area, and are able to design instructional software and to program it as well. The second approach is called top-down programming technique and is characterized by a team effort. Graef (1984) specified that while the microcomputer may be used in existing used curriculum, in order to improve problem solving and logical thinking, if to name several high cognitive skills, unfortunately, the computer is mostly used for mastery of facts by drill and practice type software. Following the above assumptions and based on Daley and Hillier (1981), we developed a software program "The growth curve of Microorganisms" which was integrated into a modular course of an existing curriculum for 10th grade, called "The Microorganisms and Man" (Huppert, 1982). (See Flow Chart 1).

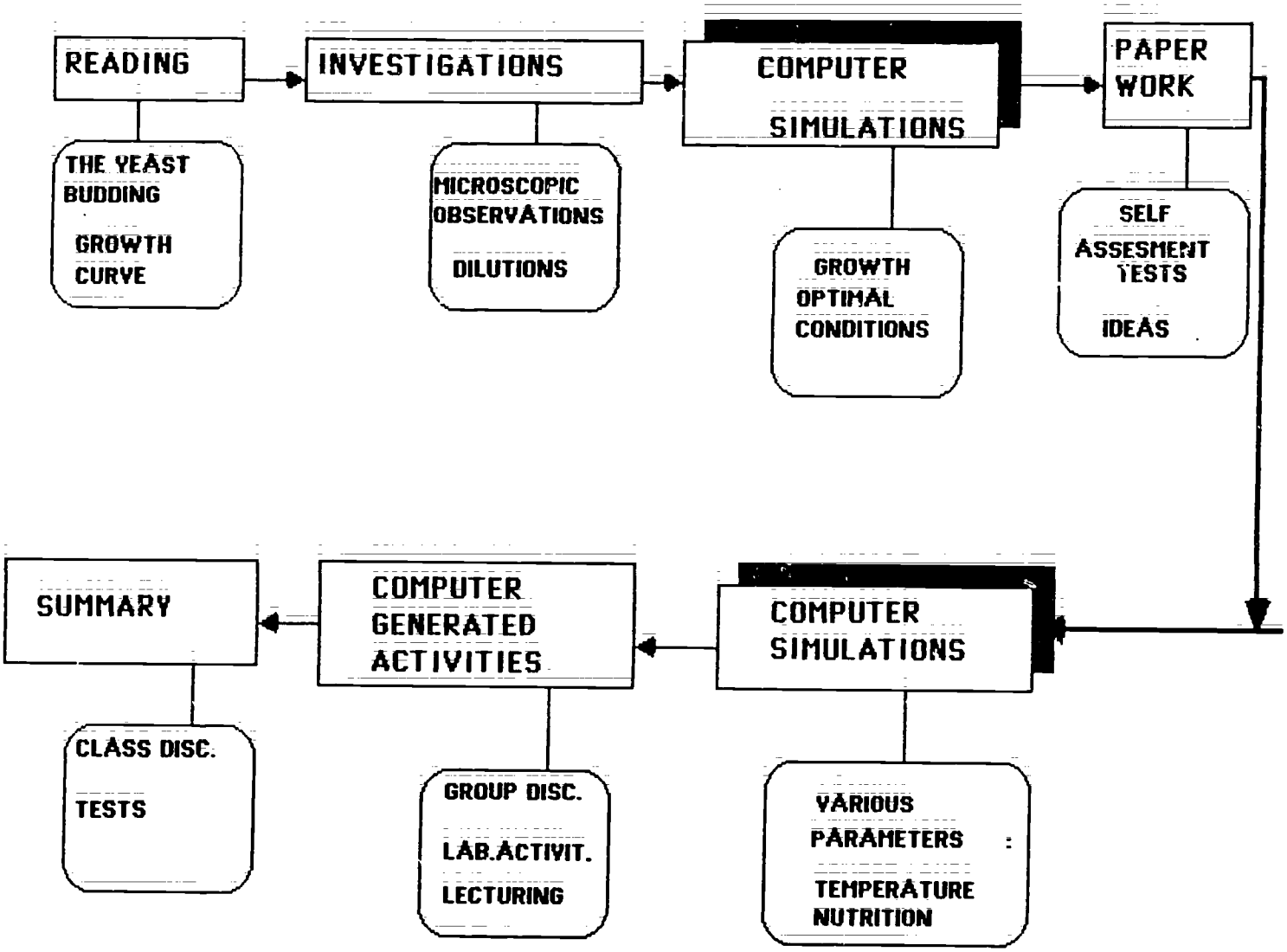
FLOW CHART 1

A MODULAR COURSE " MICRO-ORGANISMS AND MAN "



AN INDIVIDUALIZED C A L UNIT "MICROBIAL GROWTH CURVE"

ACTIVITIES FLOW CHART



This paper will describe:

1) The sequence of the developmental steps of the software program for high school. 2) A short description of the program "The growth curve of micro-organisms". 3) A short description of the implementation of this software program in 10th grade high school biology, and classroom management problems.

These three parts will be presented, based on the experience acquired during the development, as well as during the implementation process in several high school classes.

1. The sequence of the developmental steps of a software program for high school

a) The basic assumptions:

One way of using the microcomputer in the classroom is to develop short software programs which can be integrated into an existing curriculum. This approach, which is known as Computer Assisted Learning (CAL), can be efficient if it is based on the following criteria:

- The topics which are chosen should be of such a nature that they either cannot be taught without a microcomputer or if they were to be taught by another instructional approach they would be presented with many gaps. (For example: long term experiments, the need of expensive laboratory equipment, etc.).
- The program should be flexible enough to be used as a short independent learning unit in addition to serving as part of an existing course.
- The program should be structured in a way that either individuals or small groups of students can study it. In this way two important instructional strategies can be used: (1) the individual learning approach, and (2) the cooperative learning approach. Both emphasize affective and social aspects of the learning process.
- The program should initiate various learning activities such as paper work, performing additional experiments, etc.

b) Developing a software program - a team task:

How to form a team of developers?

Since our approach is based on school-based curriculum, the team of developers should consist of local teachers which show the following characteristics:

- Broad knowledge of the subject-matter.
- Teaching experience which includes awareness of students' and local needs.
- Basic awareness of the computer, including basic knowledge in programming, as well as awareness of the advantages and disadvantages of a microcomputer in relation to the cognitive, affective and social aspects of the classroom learning process.

How the team works?

The developing team worked in the following pattern:

- Identification of the topic to be developed
- Forming of sub-groups for dealing with the different parts of the program, i.e. introduction, core unit, extention activities, tests, etc.
- After concluding the above steps, the formation of sub-groups which meet together and each group reported on the whole team. Discussions and suggestions followed.
- The framework of the program was suggested.
- Following the interaction of the sub-groups the learning program was handed to the programmer who prepared the first draft of the software.
- The first edition of the program was submitted to the team for discussion, changes, editing, revising, etc. This stage was repeated several times.

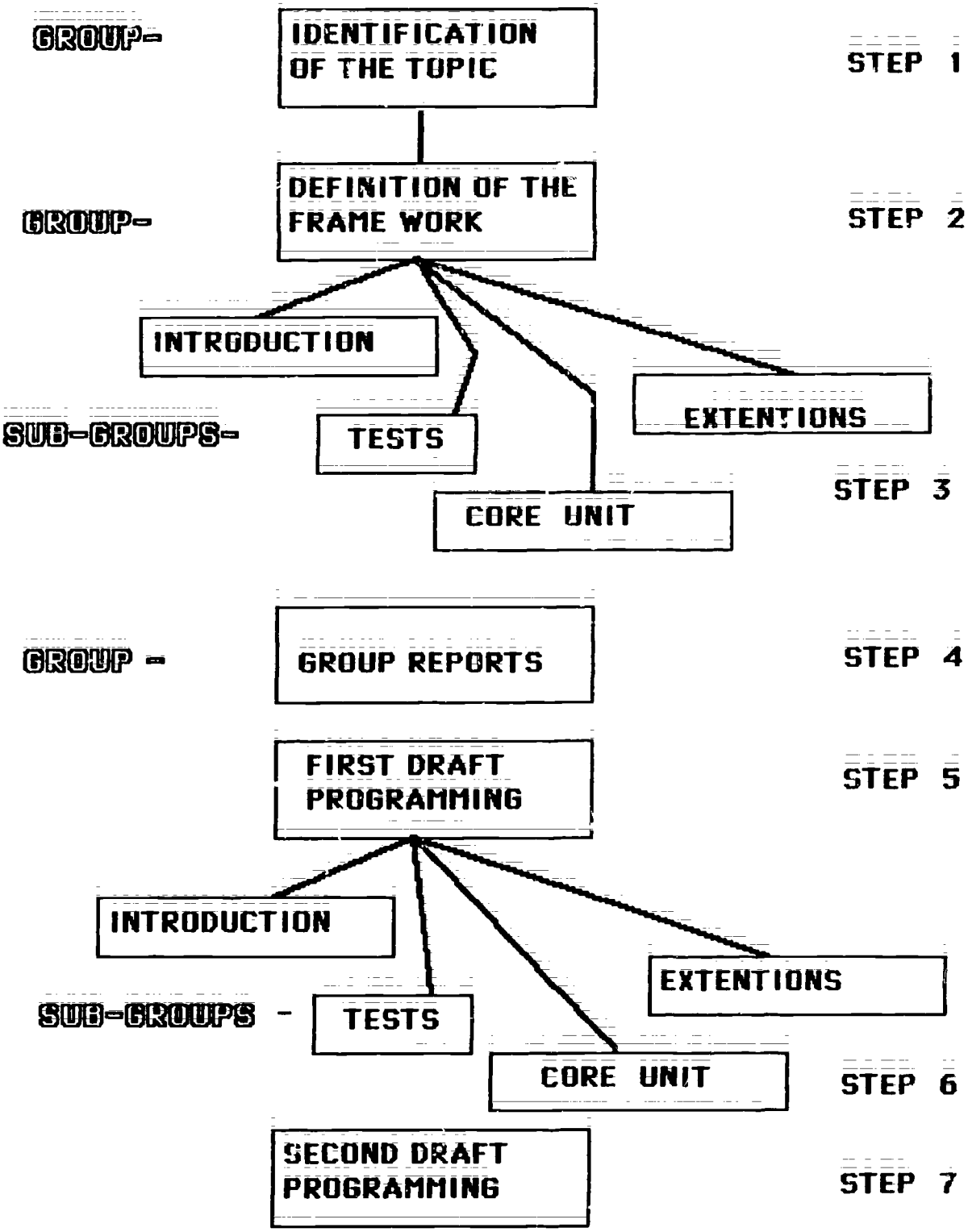
All the steps described above are presented in Flow Chart 2.

2. A description of the Software "The growth curve of the Microorganisms" A simulation

The Biology of Microorganisms is one of the important subjects taught at the junior college and high school level. While the cell structures and physiology of microorganisms can be studied in the regular course sites of the classroom and laboratory work, some other aspects cannot be always taught because of different reasons. One of the aspects neglected is the issue of the "Growth Curve", since its' study requires several long term laboratory sessions, materials and equipment which is not always available. The study of this topic is important, since it enables students to investigate the nature of the growth process of microorganisms and also to study about the impact of various environmental variables such as temperature, nutrient concentration, etc. on the population growth.

FLOW CHART 2

DEVELOPING A SOFTWARE PROGRAM - A TEAM TASK



Our goal was to use the microcomputer for experiment simulations as a tool for overcoming the shortage of time, material and equipment and to use it in the same time for high cognitive level activities in the instructional process. Simulating experiments requires students to exhibit specific skills such as skills of decision making and problem solving.

The modular course included classroom instruction in which students learned the characteristics of the microorganisms, such as their structure, the life processes and other related facts. The students became acquainted with the definition of population, generation time, lag phase and exponential phase of the growth of microorganisms.

In laboratory work students examined yeast cells under a light microscope, studying their reproduction and budding process and learnt how to count cells with a haemocytometer. Students learnt also how to dilute yeast cell culture and how to calculate the actual cell number in the sample.

The simulation program made possible to perform many "experiments" in a short time and to follow the influence of various factors such as temperature, nutrient conditions etc. on the growth curve in a very short way.

The microcomputer simulation was integrated into the sequence of the learning activities in the classroom and laboratory, which were performed at the students' own pace.

The following steps were studied in the computer simulations:

a) students were required to feed data into the computer related to the initial conditions of the yeast cells growth. The data included different temperatures, different nutrient concentration and different initial number of cells of the culture.

b) students counted the number of cells as they were exposed on the screen in a frame of a simulated haemocytometer under various growth conditions as mentioned above.

c) students were asked to plot the results of the population growth in order to form a graph of a growth curve on the screen, and were required to analyse the results obtained in the simulation program by using a worksheet. The concepts of a population growth curve such as the lag, log stationary phase were explained in the worksheet and helped the students to interpret the graph results.

In the following step students were required to count the initial yeast cells sample again, which was kept at a constant temperature. The students had to define (with the use of the graph obtained earlier) the growth phase of the original yeast culture.

Computer Generated Assignments - Within this frame, students were required to apply the growth curve pattern to other populations and to hypothesize the impact of external factors on a population growth curve. Then the hypotheses suggested in the above step served for classroom discussion.

The CALU included a self-assessment test with twelve multiple-choice questions. The following procedures were sequenced in the test. When the students chose a wrong answer they were not able to try for another answer or to pursue a new question. Instead, they were given remedial instruction for the particular knowledge regarding the question. Following this reiteration the program allowed them to continue and to try to answer again. If after this second attempt they succeeded to select the correct answer the program allowed them to pursue the following question. In case of a mistake at the second attempt the student was asked to consul` the teacher.

3. The Implementation Process of the CAL Program in the Classroom

Three factors should be considered in relation with the implementation process:

1) The classroom setting: The laboratory classroom setting was made suitable for individualized or small group learning. The computers were situated in different corners of the laboratory and so was the necessary equipment. No special lessons were used to work on the simulation program and therefore it was studies in a regular biology lesson held in the laboratory classroom.

2) The student: The program "Growth curve" was used as part of a modular course "Microorganism and Man". This course was based on self-paced student progress. The students worked on different assignments at the same time, progressing at their own pace. The simulation program "Growth Curve" was integrated into the learning process of the module as one of the various assignments. Three Apple IIe microcomputers were available in the laboratory and the students worked independently (or in small groups) on the simulation program.

3. The self-paced progress enabled the efficient use of the computer time. In Flow Chart 3 students self-paced activities are presented.

3) The teacher: The self-paced study of the simulation program urged certain changes in the teachers role in the classroom. The teacher was now expected to be able to manage a more complicated learning structure and to be able to manage successfully the use of a microcomputer. The teacher was acting more as an advisor than as a source of knowledge. During the classroom discussions held as a summary of the simulation program the teacher was acting as a motivator to help the students to gain an overall picture of the programs' concept - "The population growth curve". These activities are presented in Flow Chart 4.

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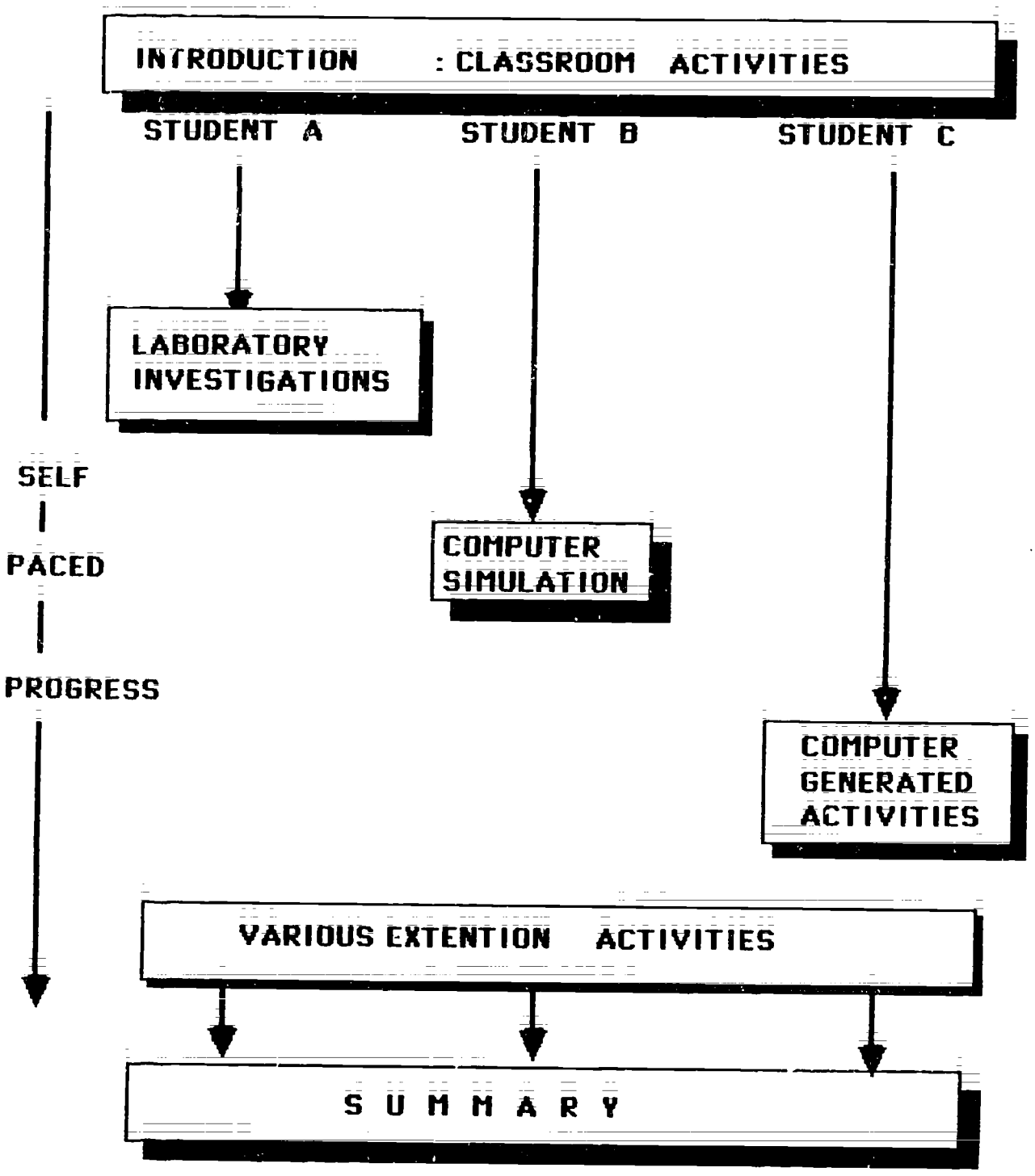
FLOW CHART 3

THE CLASSROOOM MANAGEMENT

OF AN INDIVIDUALIZED C A L UNIT IN BIOLOGY

THE SELF-PACED PROGRESS ENABLES AN EFFICIENT USE OF THE COMPUTER TIME



FLOW CHART 4

LEARNING MODE OF THE COMPUTER COURSEWARE

THE GROWTH CURVE