THE DEVELOPMENT OF AN INSTRUCTIONAL PACKAGE, FOR THE GRADE X CREDIT PHYSICAL EDUCATION PROGRAMME, ENTITLED "MEASURING FITNESS"

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LA THÈSE A ÉTÉ MICROFILMÉE TELLE QUE NOUS L'AVONS RÉCEVE
THE DEVELOPMENT OF AN INSTRUCTIONAL
PACKAGE, FOR THE GRADE X CREDIT PHYSICAL EDUCATION
PROGRAMME, ENTITLED "MEASURING FITNESS"

by

Colin Higgs, B.Sc., M.Sc.

A Thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Education

Faculty of Education,
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Memorial University of Newfoundland

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St. John's Newfoundland
ABSTRACT

Using an instructional development model, an instructional package was developed for use in the Province of Newfoundland's Grade X credit physical education programme. A survey of teachers indicated that the subject areas:

i. Measurement of fitness.
ii. Maximum oxygen uptake test.

were considered most needing of additional instructional materials. A further survey indicated that the preferred instructional media was a student booklet.

The booklet was produced and refined through a process of formative evaluation in which changes were suggested by content, learner and media experts, and by a sample of learners.

A summative evaluation was undertaken using a two-group design in which group A undertook a pre-test, studied the material and then took a post-test, while group B studied the material and then
took the post-test. Basic biographical data was collected from both groups.

The results indicated that by virtue of the instructional package learning occurred to a significant degree and that post-test scores were not affected to a significant degree by exposure to the pre-test or by the student's previous or concurrent exposure to high school biology.

It was concluded that the instructional package met the pre-determined criterion of acceptable performance in that greater than 80% of the sample achieved success on 80% or more of the stated behavioral objectives.
Acknowledgements

I would like to take this opportunity to thank all of those people who helped make this study possible. For their help during the production of the booklet, my special thanks to Mr. J. Saunders, Mr. H. Roach and Mr. M. Wells - many of their suggestions were incorporated in the text, but I, not they, am responsible for any errors of omission or commission which remain.

My thanks also to the faculty and students of the Division of Learning Resources, Memorial University of Newfoundland, for their support and to all of the students who acted as subjects.

Lastly my thanks to Mavis, without whom this would not have been completed.

Colin Higgs
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CHAPTER I
BACKGROUND TO THE PROBLEM

Of all subjects included in the curriculum of Newfoundland's schools only physical and religious education are required by law (Government of Newfoundland 1968). This can be seen as an indication of the importance of these subjects in the eyes of the Province's legislators.

Historically, within the schools of Newfoundland, physical education has been a recreational, non-credit, activity to which the pupils were exposed relatively infrequently at the higher grade levels.

However, this state of affairs was altered in 1973 when some concerned physical education teachers approached the Department of Education to see if it was possible to launch a credit programme in physical education at the high school level, specifically in Grade X. The Department was cooperative and in 1974 the first pilot project was started in the St. John's area.

The Grade X pilot project was designed to cover both practical and theoretical aspects of physical education with a time allocation of four periods of forty minutes.
per week! The time was divided as follows:

25% Applied physiology
75% Practical activities.

During the first three years of the pilot programme, a student manual was written by the Department of Education in conjunction with involved teachers (Saunders, 1976).

In 1977 this manual was mass produced and was distributed to each of the 14 schools involved in the Grade X programme and also to the 7 schools involved in the more recently inaugurated Grade XI programme.

Rapid expansion of the number of schools and pupils involved in the programme occurred in 1978 and initial responses show that for 1979 there will probably be an even greater rate of expansion. This year, 1978, pupils will write Grade XI public examinations in the subject for the first time. Hope has been expressed that by 1982 physical education will be a compulsory credit programme.

Mr. J. Saunders, Physical Education Consultant for the Provincial Department of Education, and one of the people most concerned with the introduction of the credit programme and the writing of the course manual has stated:

---

1Private conversation with Mr. J. Saunders, Physical Education Consultant, Province of Newfoundland, held fall 1978.
that the biggest handicap to the credit programme has been the lack of suitable material in the realm of applied physiology.

Within this general area more specific subject matter has been singled out as being particularly lacking, the single most pressing being that of the conceptualization of the theory of physical fitness testing, the testing of fitness and the interpretation of test scores.

Needs Assessment

With the greatest perceived need seen as being in the area of physical fitness testing, with special emphasis on the conceptualization of the theory underlying cardio-vascular respiratory fitness tests, a more detailed investigation of need was undertaken.

The nature of the instructional problem and the need was related closely to the concept of fitness (and thus fitness testing) expressed in the Grade X programme manual. Now, while no statement of the concept of fitness is made in the student manual (Saunders, 1977), certain clues do exist. On page 37 the following statement can be found:

We can generally establish as a satisfactory level of physical fitness the standard of 50 ml/s (sic) of O2 consumed per kilogram of body weight per minute.
This is a clear indication that the concept of fitness is based upon what is known as maximum oxygen uptake; that is, a measure of the body's ability to use oxygen to break down foods to produce usable energy.

This concept, and the tests based on it, have a long and honourable history of scientific acceptance as the single best indicator of a person's physical fitness level. (Astrand and Saltin, 1961)

The score obtained by an individual on a test of maximum oxygen uptake is known as his/her Max. VO₂.

With this in mind the need can be expressed more finitely as follows:

i. A need for the student to understand the biological functions involved in the capture and utilization of oxygen.

ii. A need for the student to understand the limitations of the body to use the oxygen surrounding it.

iii. A need for the student to understand that the concept of fitness is that cardio-vascular respiratory fitness is a function of the ability of the body to capture and utilize oxygen.

iv. A need for the student to understand that test, called a maximum oxygen uptake test, can measure the ability of the body to capture and utilize oxygen.
v. A need for the student to understand the rationale behind, and the methodology of, the maximum oxygen uptake test.

vi. A need for the student to be able to calculate a Max. VO₂ score when given the appropriate data.

vii. A need for the student to be able to interpret a Max. VO₂ score in terms of its indication of level of fitness.

To further substantiate need, 13 physical education teachers involved in teaching the Grade X programme were interviewed by the author. All thirteen of the teachers completed a questionnaire (see Appendix A) concerning the areas of the applied physiology programme which the teachers felt required additional instructional material.

Each teacher was requested to indicate (in rank order) the three areas which he or she considered most in need of additional material. The subject selected as being most in need by a teacher scored 3 points with 2 and 1 point(s) going to the second and third choice.

Table I shows the point scores for each of the nine subject areas as well as the final composite rankings.

From Table I it can be seen that the three highest ranked subject areas were:

1. Measurement of fitness
2. Maximum oxygen uptake test
3. The functioning of the heart.

TABLE I
POINT TOTALS AND FINAL RANKINGS FOR
EXPRESSED NEED FOR VARIOUS SUBJECT AREAS

<table>
<thead>
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<th>Area</th>
<th>Total points</th>
<th>Final rank</th>
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<tbody>
<tr>
<td>Function of the heart</td>
<td>16</td>
<td>3rd</td>
</tr>
<tr>
<td>Function of the lungs</td>
<td>9</td>
<td>4th</td>
</tr>
<tr>
<td>Function of muscles</td>
<td>1</td>
<td>7th</td>
</tr>
<tr>
<td>Function of blood</td>
<td>4</td>
<td>5th</td>
</tr>
<tr>
<td>Measurement of fitness</td>
<td>23</td>
<td>1st</td>
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<tr>
<td>Maximum oxygen uptake test</td>
<td>19</td>
<td>2nd</td>
</tr>
<tr>
<td>Measurement of strength</td>
<td>1</td>
<td>7th</td>
</tr>
<tr>
<td>Measurement of flexibility</td>
<td>0</td>
<td>9th</td>
</tr>
<tr>
<td>Long term effect of exercise</td>
<td>4</td>
<td>5th</td>
</tr>
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</table>

The three top ranked areas were clearly considered more important than any of the remaining areas by the teachers involved in the survey. These teachers represented almost half (approx. 46%) of the teachers known to be involved in the Grade X programme.

Based on the 28 schools listed by the Dept. of Education (Newfoundland) as offering the Grade X programme in October 1979. This may well be an under estimate of the true number.
The survey results clearly support the expressed opinion of the Provincial physical education consultant and established beyond reasonable doubt the need for additional instructional materials in the area of measurement of fitness and maximum oxygen uptake testing.

Alternative Solutions

Three distinct alternative solutions to meeting the instructional need were considered. These were:

i. To bring the testing materials, personnel and expertise to the schools.

ii. To take the students to an institution in which the materials, personnel and expertise were available.

iii. To obtain or produce an instructional package, covering the appropriate materials, for use in schools.

The first alternative, performing the Max. VO₂ test in the schools, was rejected on two grounds. In the first instance the test itself is stressful for the subject to a degree which the schools would find unacceptable. Secondly the equipment required to perform the test is expensive (in the order of $10,000 to $15,000).
and requires highly trained operators.

The second alternative, taking the pupils to institutions where the test could be performed, was also rejected. At the present time only Memorial University of Newfoundland and a few of the larger hospitals in the Province have the required equipment. Even if arrangements could be made to use this equipment only a very small percentage of the total student population would have access to it. Thus this alternative was not considered viable.

The third alternative, and the preferred approach, was to obtain or produce a suitable instructional package.

Available Material

A thorough, ongoing, search by the author, the Provincial physical education consultant and the teachers involved in the Grade X programme failed to locate any materials suitable either with respect to content or grade level, most of the texts having been written for senior level university courses.

Thus the decision was made to produce an instructional package. From the results of the survey (Table I) it was decided to limit the scope of the instructional package to the areas of measurement of fitness and the maximum oxygen uptake test.
Rationale for Development

The rationale for development was based upon the sequential relationship between the component parts. All comprehension of the maximum oxygen uptake test is based, ultimately, on an understanding of the biological phenomena involved.

Thus a four part approach was selected.

Part I

a. A review of the individual biological functions.
b. An integration of the biological changes induced by exercise.
c. An explanation of the factors limiting the severity of work which a person can perform.
d. The relationship of the factors in (c) above to the maximum oxygen uptake test.
e. The theory of the maximum oxygen uptake test.

Part II

a. The presentation of the stages of a maximum oxygen uptake test.
b. The recording of data from tests.
Part III
a. The calculation of a Max. VO₂ score from data supplied.

Part IV
a. The interpretation of test scores.

This rationale imposed several restraints, the most serious of which concerned the student's ability to progress through the material. The important consideration was that due to a variety of backgrounds and abilities the instructional package would have to allow each student to progress at his/her optimal rate.
CHAPTER II
LEARNER ANALYSIS

The education process is a complete interaction between all of its component elements. Perhaps the most important of the elements is the learner himself. The view has been expressed (Lindgren, 1967) that:

The learner is important...not only because people are more important than processes or situations but primarily because without the learner there is no learning.

Thus, those characteristics of the learner which have a bearing on his ability to learn had to be considered by the developer of the instructional package.

General Characteristics

The instructional package was developed for use as an integral part of the Grade X credit physical education programme in the Province of Newfoundland and thus the target population was clearly and closely defined.
In general the pupils fell within the age range of 15-17 years, and by virtue of their Grade X promotion were considered to be literate to the extent of reading and writing general, non-technical, material. Also they were considered capable of mathematics, at least within the realm of simple arithmetic functions. This is not to say that many of the students did not have abilities and skills far beyond those listed. Those stated represent the minimum accomplishment for any member of target population.

Within the specific field of physical education the students had no common core of knowledge. Prior to Grade X they had undertaken a variety of Grade IX physical education programmes. For most of the students there had been no class-room, or academic, component of the programme. This precluded, for the most part, the acquisition of technical information concerning fitness testing.

At the Grade X level all students had worked from the Department of Education’s publication, The Human Energy System, (Saunders, 1977) to a greater or lesser degree and thus can be considered tentitively familiar with it. The
section, "Measuring Physical Fitness" (page 29) is basically descriptive and gives an overview of the types of test which can be performed. It contains neither an explanation of the rationale for the tests or detailed instructions concerning the performance of the tests. Thus for the purpose of the design of the instructional package it was considered that knowledge of maximum oxygen uptake testing was minimal or non-existent in the target population.

Specific Relevant Background

Even though no knowledge of the maximum oxygen uptake test was assumed, this did not mean that all of the target population entered the instructional material with the same (i.e. zero) background knowledge.

The maximum oxygen uptake test is based on the relationship between the cardio-vascular and the respiratory systems of the body. Comprehension of the test is dependant on a working knowledge of these systems. Such knowledge might be acquired, by a proportion of the students, in high school biology classes. In view of this, strategies to bring all of the target population to an adequate level of biological knowledge were considered essential.
Student Attitudes

No hard data was available concerning the attitudes of the students towards physical education. Certain inferences can, however, be drawn. It should be noted that physical education, at this point in time, is an optional subject and that the students had opted to participate of their own free will.

It should also be noted that the number of schools undertaking the programme has increased rapidly and that many of the schools which started out with only a Grade X programme have now expanded to include Grade XI.

All of the above support the inference that attitudes towards the subject were probably positive.

Implications.

The learner analysis indicated that the following points were of importance. All were considered during the production of the instructional package.

i. That normal descriptive language of a level suitable for Grade X students could be used.

ii. That all technical terms needed to be defined and explained as a knowledge of any such terms could not be assumed.
iii. That all required biological background material needed to be included and that such material
needed to be constructed in such a way that it would serve as review material for those with a biological
background while at the same time serving as instructional material for the remainder.

iv. That the students had the arithmetic skills to deal with the calculation of the Max. VO2 score
provided that the method of calculation was presented.

v. That the students had an attitude positive towards the subject matter and that therefore the pro-
duction of attitude change material was not required.
CHAPTER III

TASK ANALYSIS

A task analysis was undertaken using temporal sequential flowcharting. That is, the elements to be mastered were placed in the temporal sequence most likely to lead to the desired learning outcomes.

To this end the overall requirements of the package were divided into four sub-packages which could be sequentially ordered.

The four sub-packages were:

i. The biological concepts underlying the maximum oxygen uptake test.

ii. The apparatus and methodology of the maximum oxygen uptake test.

iii. The calculation of Max. VO₂ from test data.

iv. The interpretation of the test scores.

Figure 1 shows the relationship of the four sub-packages to the overall package, while figures 2 to 5 show the components within each of the sub-packages.
Task Analysis

- Maximum oxygen uptake TEST
  - BIOLOGICAL FOUNDATIONS
  - Mechanics of Max. VO₂ Testing
  - Calculation of Max. VO₂
  - INTERPRETATION OF TEST RESULTS
Figure 4
Each of the figures (1-5) is a flow chart and can be read in the same way. Starting from the top of the chart the solid pathway is followed until branching occurs. At any branching point the earliest material in the sequence is that presented furthest to the left. The material in the block furthest left is completed prior to starting on the next block to the right. Where more than one item appears at the same horizontal level that to the left is the earliest.

Assumptions and Entry Behaviour

By virtue of the nature of the credit physical education programme it appeals to students of a variety of abilities and backgrounds. Some have an in-depth background in one or more of the sciences while others do not. Because of this, no common assumptions regarding background were made.

Thus, the major assumption and the sole entry requirement was that the learner was capable of reading at a level appropriate for Grade X and that they be capable of performing simple arithmetic computations.
Behavioural Objectives

All behavioural objectives were constructed such that they were suitable for testing using pencil and paper tests. The five sub-sets of objectives represent one sub-set for each of the sub-packages with one sub-set for the overall instructional package.

The criterion for acceptable performance, for the instructional package, was that 80% of the sample of the target population would achieve 80% (or more) of the objectives.

Sub-set I

That given a diagram of the circulatory and respiratory systems, along with names of the anatomical parts, the student will be able to match parts and names correctly. The following anatomical parts to be tested.

a. The heart.

b. Veins.

c. Arteries.

d. Trachea.

e. Bronchioles.

f. Alveoli.
h. Capillary.

That in an objective test the student will correctly answer questions covering the following material.

j. The function of the lungs is to extract oxygen from the air.

k. That the oxygen passes through the walls of the lungs and into the capillary (blood).

l. That the blood entering the lungs contains very little oxygen.

m. That the blood leaving the lungs is full of oxygen.

n. That however fast the blood flows through the lungs it leaves full of oxygen.

o. That muscles need food and oxygen to produce energy.

p. That the harder a person works the more oxygen he uses.

q. That if the muscles do not get the oxygen they need they are forced to stop working.

r. That the heart pumps oxygen rich blood to the muscles.
s. That how much blood the heart is able to pump will determine how hard a person can work.

t. That there is a limit to how much oxygen rich blood the heart is able to pump per minute.

u. That the amount of oxygen rich blood which arrives at the muscles determines how much work a person can do.

v. That the maximum amount of oxygen a person can use per minute is a measure of how fit he is.

w. That the maximum amount of oxygen a person can use is called his maximum oxygen uptake.

x. That different size people need different amounts of oxygen to do the same amount of work.

y. That to get a Max. VO₂ score the amount of oxygen used in a minute is divided by the subject's weight.

z. That Max. VO₂ is measured in ml. O₂/kg/min.

Sub-set II

a. That given a list of all of the steps in the performance of a maximum oxygen uptake test the student will be able to place them in the correct order.

b. That the student will be able to identify the four essential measurements which must be made to obtain a Max. VO₂ score.
c. That the student will identify that Max. VO₂ measurements are made in the last minute of strenuous exercise.

Sub-set III

a. That given the amount of gas exhaled per minute, the percentage of oxygen in that gas, the oxygen content of inspired air and the weight of the subject, the student will be able to calculate a Max. VO₂ score. The formula for the calculation will be given.

Sub-set IV

a. That given a set of Max. VO₂ scores the student will be able to place them in categories of excellent, desirable, fair and poor fitness levels with 80% accuracy.

Sub-set V

a. That the student will be able to state that the maximum oxygen uptake test is the best available measure of physical fitness.

b. That the maximum oxygen uptake test is a measure of how well the body can extract oxygen from the air.

c. That the maximum oxygen uptake test is a measure of the heart's ability to pump blood.
d. That most other fitness tests are only estimates of maximum oxygen uptake.

e. That the maximum oxygen uptake test is a very strenuous test that should only be performed after the subject has had a medical examination.

f. That Max. VO₂ scores can be improved by training.¹

¹All objectives are referred to by their sub-section Roman numeral and by their letter sub-script. That is V₂.
CHAPTER IV

CHOICE OF MEDIA

The selection of a medium or media combination was dictated by three independent factors. These were:

i. The effectiveness of alternate media;

ii. Production constraints;

iii. User constraints.

Media Effectiveness

Thirteen physical education teachers, representing 46% of the teachers known to be involved in the Grade X credit programme were asked to rate each of 11 media/media combinations with regard to their effectiveness. Specifically, they were asked to rate their effectiveness in the teaching of applied physiology. A questionnaire utilizing a three-point rating scale was used. The ratings were: 1-effective, 2-neutral and 3-ineffective. For questionnaire see Appendix B.
For each of the media/media combinations a group mean rating was calculated. Table II shows the media and their respective perceived effectiveness.

### Table II

<table>
<thead>
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<th>Media</th>
<th>Effective</th>
<th>Neutral</th>
<th>Ineffective</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio tapes</td>
<td></td>
<td></td>
<td></td>
<td>2.8</td>
</tr>
<tr>
<td>Slides</td>
<td></td>
<td></td>
<td></td>
<td>1.7</td>
</tr>
<tr>
<td>Filmstrip</td>
<td></td>
<td></td>
<td></td>
<td>1.8</td>
</tr>
<tr>
<td>Video-tape</td>
<td></td>
<td></td>
<td></td>
<td>1.2</td>
</tr>
<tr>
<td>Student</td>
<td></td>
<td></td>
<td></td>
<td>1.3</td>
</tr>
<tr>
<td>Booklet</td>
<td></td>
<td></td>
<td></td>
<td>1.3</td>
</tr>
<tr>
<td>Slide+tape</td>
<td></td>
<td></td>
<td></td>
<td>1.6</td>
</tr>
<tr>
<td>Slide+script</td>
<td></td>
<td></td>
<td></td>
<td>1.6</td>
</tr>
<tr>
<td>Filmstrip+tape</td>
<td></td>
<td></td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>Filmstrip+script</td>
<td></td>
<td></td>
<td></td>
<td>1.6</td>
</tr>
<tr>
<td>Booklet+slide+script</td>
<td></td>
<td></td>
<td></td>
<td>1.2</td>
</tr>
<tr>
<td>Booklet+script+filmstrip</td>
<td></td>
<td></td>
<td></td>
<td>1.3</td>
</tr>
</tbody>
</table>

Group Mean rating

| 1 | 1.5 | 2 | 2.5 | 3 |
from Table II it can be seen that media combinations
which were considered to be most effective were:

i. Video-tapes

ii. Booklet + slides + script

iii. Slide + tape

iv. Booklet + filmstrip + script

v. Student booklet only.

It should be noted that i and ii were joint equal
first choices while iii, iv and v all scored equally
and were only slightly behind the leading two. On this
basis any one of the five listed media/media combinations
would have proved satisfactory with regard to effectiveness.

Production Constraints

Because of technical and financial limitations,
certain media were considered to be beyond the scope
of the author. Both 16mm and Super 8mm movie film
were discounted on these grounds. All remaining media
(i.e., those included in the survey) were considered
feasible.
User Constraints

In addition to rating effectiveness, the 13 teachers were asked to make a rating concerning the practicality of each medium/media combination in their own school situation. A three point rating of 1-practical, 2-neutral and 3-impractical was used. (For details see questionnaire Appendix B)

Table III shows the practicality ratings.

TABLE III
THE PERCEIVED PRACTICALITY OF 11 MEDIA/MEDIA COMBINATIONS

<table>
<thead>
<tr>
<th>Media</th>
<th>Practical</th>
<th>Neutral</th>
<th>Impractical</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio-tapes</td>
<td></td>
<td></td>
<td></td>
<td>1.4</td>
</tr>
<tr>
<td>Slides</td>
<td></td>
<td></td>
<td></td>
<td>1.8</td>
</tr>
<tr>
<td>Filmstrip</td>
<td></td>
<td></td>
<td></td>
<td>1.1</td>
</tr>
<tr>
<td>Video-tapes</td>
<td></td>
<td></td>
<td></td>
<td>2.8</td>
</tr>
<tr>
<td>Student Booklet</td>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td>Slide + tape</td>
<td></td>
<td></td>
<td></td>
<td>2.2</td>
</tr>
<tr>
<td>Slide + script</td>
<td></td>
<td></td>
<td></td>
<td>1.4</td>
</tr>
<tr>
<td>Filmstrip + tape</td>
<td></td>
<td></td>
<td></td>
<td>2.6</td>
</tr>
<tr>
<td>Filmstrip + script</td>
<td></td>
<td></td>
<td></td>
<td>1.2</td>
</tr>
<tr>
<td>Booklet + slide + script</td>
<td></td>
<td></td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>Booklet + filmstrip + script</td>
<td></td>
<td></td>
<td></td>
<td>1.3</td>
</tr>
<tr>
<td>Group Mean</td>
<td>1 1.5</td>
<td>2 2.5</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
From Table III it can be seen that video-tapes, slide + tape and filmstrip + tape must be discounted due to the virtual consensus regarding the impracticality of these media in Newfoundland's schools.

The media considered most practical by the teachers were:

i. Student booklet
ii. Filmstrip
iii. Filmstrip + script.

Direct questioning of the respondents concerning their preference of media gave inconclusive results as the expressed differences between those listed above was slight.

Selection of Media

Resolution of the divergent viewpoints concerning choice of media was achieved using a three stage process.

Stage One - From the eleven listed media/media combinations those which were unsuitable on production grounds were eliminated.

Stage Two - Those media which were considered ineffective (audio-tapes) and/or impractical (video-
tapes) were eliminated.

Stage Three - A combined effectiveness-practicality, EP-score, was calculated for each medium/media combination. In both the effectiveness and the practicality ratings, a low score was "better" and represented a more ideal medium.

Equal weighting was given to both effectiveness and practicality and the EP-scores were calculated by finding the product of the mean effectiveness rating and the mean practicality rating for each medium/media combination. In this also, a lower score represents a more ideal medium.

It should be noted that the EP-scores have a theoretical range of one to nine, with one representing an ideal medium/media combination and nine representing an impractical and ineffective medium/media combination.
## TABLE IV

**EP-Scores for 11 Media/Media Combinations**

<table>
<thead>
<tr>
<th>Combination</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio-Tapes</td>
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</tr>
<tr>
<td>Slides</td>
<td>3.06</td>
</tr>
<tr>
<td>Filmstrip</td>
<td>1.98</td>
</tr>
<tr>
<td>Video-Tapes</td>
<td>3.36</td>
</tr>
<tr>
<td>Student Booklet</td>
<td>1.30*</td>
</tr>
<tr>
<td>Slide + tape</td>
<td>2.86</td>
</tr>
<tr>
<td>Slide + script</td>
<td>2.24</td>
</tr>
<tr>
<td>Filmstrip + tape</td>
<td>3.90</td>
</tr>
<tr>
<td>Filmstrip + script</td>
<td>1.92</td>
</tr>
<tr>
<td>Booklet + slide + script</td>
<td>1.80</td>
</tr>
<tr>
<td>Booklet + script + filmstrip</td>
<td>1.69</td>
</tr>
</tbody>
</table>

*The preferred medium.

From Table IV it can be seen that the student booklet has a score which most nearly approaches the ideal. On the basis of this score a decision was made to produce the instructional package in the form of a self contained student booklet.
CHAPTER V

PRODUCTION AND FORMATIVE EVALUATION

The instructional booklet was produced within certain constraints imposed by the facilities and equipment available to the author and by the proposed method of later mass production.

It was decided that, at least until the completion of the summative evaluation, all reproduction would be by way of Xerox copies. Because of this, all illustrations were limited to black and white line drawings.

All page masters containing illustrations were produced on 16" x 12" paper, with the hand-produced line drawings being overlaid with text produced on an I.B.M. typewriter using ORATOR typeface. The page master was then photographically reduced to a standard 8½" x 11" paper size.

In all cases bold headings and key words were
produced using dry transfer letters.

Formative Evaluation

Formative evaluation was undertaken using a two stage approach. First, the material was studied by (a) a content expert who was asked to scrutinize the material with respect to the accuracy of the factual content. (b) learner experts who were asked to study the material with emphasis on the suitability of the material for the proposed target population. (c) a media expert who was asked to make comment on the clarity and effectiveness of the use of the chosen media.\(^1\)

Secondly the material was used by a group of twenty-five Grade X students enrolled in credit physical education classes at two schools.

In the case of the content, learner and media specialists an interview between the specialist and the author was arranged and at which all suggestions for improvement were recorded. All improvements suggested by the specialists were incorporated into a second draft used by the students.

In the case of the students the author administered the instructional package during a regularly scheduled class period. At the end of the period of study the students were asked to indicate, on a blank sheet provided, the best and worst aspects of the instructional package.

\(^1\)For details of specialists see Appendix F.
In addition, the students were asked to indicate which areas of the instructional package required further elaboration to aid comprehension. Information from the questions concerning the best and worst aspects was of little use as all of the comments were either highly favorable or were negative in a vague or general manner. Information from the section regarding areas which required amplification indicated that it was in the area of the calculation of Max. VO\textsubscript{2} that additional instructional material was needed.

After the inclusion of additional material covering the calculation of Max. VO\textsubscript{2}, the instructional package was considered ready for a more formal, summative, evaluation.
CHAPTER VI

SUMMATIVE EVALUATION

Through the kind cooperation of both the Avalon North Integrated and the Avalon Consolidated school boards, testing was possible in two designated schools.

The students used for the testing of the instructional package were all regular members of the Grade X credit physical education classes at their respective schools.

Table V gives basic biographical data for the students (n=53).

<table>
<thead>
<tr>
<th>SEX</th>
<th>NUMBER</th>
<th>AGE MEAN</th>
<th>STANDARD DEV.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>32</td>
<td>15.7</td>
<td>0.38</td>
</tr>
<tr>
<td>Female</td>
<td>21</td>
<td>15.4</td>
<td>0.32</td>
</tr>
<tr>
<td>Total</td>
<td>53</td>
<td>15.6</td>
<td>0.36</td>
</tr>
</tbody>
</table>
Experimental Design

All students (n=53) were randomly assigned to one of two groups. Group A (n=26) was given a pre-test, the experimental treatment (i.e., the instructional material and the time to work through it) and a post-test. Group B (n=27) were assigned a dummy pre-test, the treatment (as for group A) and the post-test. This design was used in an attempt to measure the effect of the pre-test on post-test performance.

Testing Instrument

Both groups wrote identical post-tests while group A additionally wrote the same test instrument as a pre-test.

The test instrument consisted of 31 objective questions, in the majority of which the student was required to write in a single word (or short phrase) answer. This design was used to minimize the possibility of the student making a guess at the answer.

Table VI lists the objectives which it was hoped the instructional package would meet along with the question(s) which test that objective. The notation for the objectives is consistent with that in Chapter Three.
## TABLE VI

OBJECTIVES AND THE QUESTIONS TESTING THEM

<table>
<thead>
<tr>
<th>Objective</th>
<th>Question</th>
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</thead>
<tbody>
<tr>
<td>I a</td>
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</tr>
<tr>
<td>b</td>
<td>25</td>
</tr>
<tr>
<td>c</td>
<td>26</td>
</tr>
<tr>
<td>d</td>
<td>27</td>
</tr>
<tr>
<td>e</td>
<td>28</td>
</tr>
<tr>
<td>f</td>
<td>29</td>
</tr>
<tr>
<td>g</td>
<td>30</td>
</tr>
<tr>
<td>h</td>
<td>31</td>
</tr>
<tr>
<td>i</td>
<td>1</td>
</tr>
<tr>
<td>j</td>
<td>2</td>
</tr>
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<td>k</td>
<td>3</td>
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<tr>
<td>l</td>
<td>4</td>
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<td>m</td>
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<td>v</td>
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<td>x</td>
<td>15</td>
</tr>
<tr>
<td>y</td>
<td>16</td>
</tr>
<tr>
<td>z</td>
<td>17</td>
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</tr>
<tr>
<td></td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>23</td>
</tr>
</tbody>
</table>

### Testing Procedure

All subjects were given an identification code number to be placed on their booklet, pre-test and post-test. The subjects were then randomly assigned to either group A or group B by virtue of their receiving or not receiving the pre-test. Those who did not receive the
pre-test were administered a dummy pre-test of comparable difficulty designed to take the same time to complete. The dummy pre-tests were concerned with anatomical identification and were discretely discarded following the completion of the testing procedure.

All subjects were then given one hour in which to study the material and work through the associated problems. During this period the author turned down all requests for additional information and asked the student to see him later if the information was still required. In this manner the instructional material was in no case supplemented by verbal input.

Following exposure to the instructional material all students wrote the post-test.

Included with the post-test was a very short questionnaire designed to collect basic biographical data, i.e.

i. The student's age and sex

ii. The student's exposure to high school biology.

iii. The student's attitude towards the instructional package.

iv. The student's attitude towards physical education.
Analysis of Data

The data was analysed in an attempt to answer the following questions:

i. To what extent did learning occur?

ii. Did the instructional package meet its stated objectives?

iii. What was the effect of the pre-test on post-test performance?

iv. What was the effect of exposure to high school biology on pre-test and post-test performance?

Extent of Learning Accomplishment

The degree to which learning occurred was measured in three ways.

i. By the comparison of pre-test and post-test scores.

ii. By a pre-test post-test item analysis.

iii. By the calculation of success, failure, pre-knowledge and interference indices.

Table VII shows the pre-test and post-test raw scores and percentages for group A (n=26). It should be noted that raw scores are reported as the number of scores correct out of the possible maximum of 31.
### TABLE VII

RAW SCORES AND PERCENTAGES ON PRE-TEST AND POST-TEST (GROUP A)

<table>
<thead>
<tr>
<th>Subject number</th>
<th>Pre-test scores</th>
<th>Post-test scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw score</td>
<td>%</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>22.58</td>
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<tr>
<td>2</td>
<td>3</td>
<td>9.68</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>29.03</td>
</tr>
<tr>
<td>4</td>
<td>11</td>
<td>35.48</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>22.58</td>
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<td>6</td>
<td>5</td>
<td>16.13</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>9.68</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>3.23</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>6.45</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>9.68</td>
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<tr>
<td>11</td>
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<td>12</td>
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<td>9.68</td>
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<td>9.68</td>
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<tr>
<td>15</td>
<td>3</td>
<td>9.68</td>
</tr>
<tr>
<td>16</td>
<td>1</td>
<td>3.23</td>
</tr>
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<td>17</td>
<td>2</td>
<td>6.45</td>
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<td>18</td>
<td>3</td>
<td>9.68</td>
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<td>25</td>
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<td>0.00</td>
</tr>
<tr>
<td>26</td>
<td>4</td>
<td>12.90</td>
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</tbody>
</table>

Mean 3.80 27.15 27.15 87.59
From Table VII it can be seen that the average pre-test score was 3.80 (27.15%) with an average post-test score of 27.15 (87.59%). A t-test for dependent samples was performed on the pre-test/post-test data. It indicated that the difference between the means was significant at well beyond the 0.005 level. A t-score of 31.30 was obtained with 4.31 required at α=0.005.

Thus it can be concluded that learning, as measured by scores on the test instrument, occurred to a highly significant degree.

Item Analysis

An item analysis was carried out to determine the extent to which learning occurred on each specific objective. Table VIII shows the number (and percentage) of correct responses, for pre-test and post-test, for each of the test items. The difference between the numbers scoring correctly on the post-test and pre-test was tested for significance using χ² analysis.
<table>
<thead>
<tr>
<th>Question number</th>
<th>Pre-test #</th>
<th>Pre-test %</th>
<th>Post-test #</th>
<th>Post-test %</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>25</td>
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<td>92.31</td>
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<td>7.69</td>
<td>23</td>
<td>88.46</td>
<td>180.50</td>
</tr>
<tr>
<td>24</td>
<td>22</td>
<td>84.62</td>
<td>26</td>
<td>100.00</td>
<td>0.72</td>
</tr>
<tr>
<td>25</td>
<td>10</td>
<td>38.46</td>
<td>23</td>
<td>88.46</td>
<td>16.90</td>
</tr>
<tr>
<td>26</td>
<td>10</td>
<td>38.46</td>
<td>23</td>
<td>88.46</td>
<td>16.90</td>
</tr>
<tr>
<td>27</td>
<td>2</td>
<td>7.69</td>
<td>22</td>
<td>84.62</td>
<td>200.00</td>
</tr>
<tr>
<td>28</td>
<td>1</td>
<td>3.85</td>
<td>22</td>
<td>84.62</td>
<td>441.00</td>
</tr>
<tr>
<td>29</td>
<td>3</td>
<td>11.54</td>
<td>22</td>
<td>84.62</td>
<td>120.33</td>
</tr>
<tr>
<td>30</td>
<td>3</td>
<td>11.54</td>
<td>22</td>
<td>84.62</td>
<td>120.33</td>
</tr>
<tr>
<td>31</td>
<td>3</td>
<td>11.54</td>
<td>22</td>
<td>84.62</td>
<td>120.33</td>
</tr>
</tbody>
</table>

* p<.05  ** p<.01  *** p<.001
From the item analysis it can be seen that all but two of the items showed pre-test/post-test increases which were significant at well beyond the \( \alpha=0.001 \) level. The exceptions to this were items 6 and 24. Item 6 was significant at the \( \alpha=0.05 \) level while item 24 showed no significant change. The low, and non-significance, respectively appear to be due to the very high level of pre-test performance.

In item 6, 65.38\% scored correctly on the pre-test with 100\% scoring correctly on the post-test. For item 24 the percentages were 84.62\% on the pre-test and 100\% on the post-test.

Thus it can be seen that highly significant improvements in performance were recorded on all but two of the test items. On both of the non-significant improvement items the post-test score was 100\% and thus the lack of significance was probably due to a ceiling effect. Combined, these figures indicate that learning occurred on all items.

**Success, Failure, Pre-knowledge and Interference Indices.**

For any item on which a pre-test, post-test design is used a given subject must fall into one of four categories.
That is:

i. Item incorrect on the pre-test and correct on the post-test. (II-C2)

ii. Item correct on both the pre-test and the post-test. (CI-C2)

iii. Item incorrect on both the pre-test and the post-test. (II-I2)

iv. Item correct on the pre-test and incorrect on the post-test. (CI-I2)

Now, those subjects falling into group ii have not benefited from the instructional package by virtue of their previous knowledge, while those in group iii have failed to benefit by virtue of their continued ignorance of the material after completing the package. Group i represents those who have benefited from the package while those in group iv have had previously held correct information interfered with to the extent that they gave an incorrect answer on the post-test to a question on which they had previously scored. Where an element of chance is active in the selection of an answer this group may represent those who failed to learn the material but were successful in their guess on the pre-test but later guessed unsuccessfully.
Thus, from the numbers of subjects falling into the four groups, it is possible to calculate:

a. The percentage of those who did not know the material on the pre-test who were able to score correctly on the post-test. This was defined as the success index.

b. The percentage of those who did not know the material on the pre-test and who failed to learn the material by virtue of exposure to the instructional package. This was defined as the failure index.

c. The pre-knowledge index refers to the percentage of the population which scored correctly on both the pre-test and the post-test. This group were assumed to have had previous knowledge of the material covered by the test item.

d. The interference index refers to the percentage of the population which, having scored correctly on an item on the pre-test, fails to score correctly on the post-test. It should be noted that due to the low number of subjects scoring correctly on the pre-tests a single subject then failing to
score on the post-test causes a high interference index to be obtained.

Table IX shows the four indices for each of the 31 test items.

From Table IX it can be seen that on average 89.08% of those who did not know an item on the pre-test were able to score correctly on the post-test, while 10.92% failed to do so.

Table IX also shows that on average 13.16% of the population had previous knowledge of the material covered and retained that knowledge through the post-test. It should be noted however that in actuality a very large proportion of the population scored correctly on both pre-test and post-test on only four of the test items. From the data it can also be seen that on average interference occurred in 1.12% of the population, a figure which would appear to represent a chance fluctuation in scoring.
# TABLE IX

SUCCESS, FAILURE, PRE-KNOWLEDGE AND INTERFERENCE INDICES FOR EACH ITEM

<table>
<thead>
<tr>
<th>Question number</th>
<th>Number of people per group</th>
<th>Success, Failure, Pre-Knowledge, Interference Indices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I1-C2</td>
<td>C1-C2</td>
</tr>
<tr>
<td>1</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>23</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>9</td>
<td>17</td>
</tr>
<tr>
<td>7</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>22</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>23</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
<td>15</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>19</td>
<td>2</td>
</tr>
<tr>
<td>17</td>
<td>22</td>
<td>4</td>
</tr>
<tr>
<td>18</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>19</td>
<td>24</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>22</td>
<td>2</td>
</tr>
</tbody>
</table>
TABLE IX

<table>
<thead>
<tr>
<th>Question number</th>
<th>Number of people per group</th>
<th>Success Index</th>
<th>Failure Index</th>
<th>Pre-knowledge Index</th>
<th>Interference Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>26</td>
<td>0</td>
<td>0</td>
<td>100.00</td>
<td>0.00</td>
</tr>
<tr>
<td>22</td>
<td>23</td>
<td>2</td>
<td>0</td>
<td>92.00</td>
<td>8.00</td>
</tr>
<tr>
<td>23</td>
<td>22</td>
<td>2</td>
<td>0</td>
<td>91.67</td>
<td>8.33</td>
</tr>
<tr>
<td>24</td>
<td>4</td>
<td>22</td>
<td>0</td>
<td>100.00</td>
<td>0.00</td>
</tr>
<tr>
<td>25</td>
<td>14</td>
<td>9</td>
<td>2</td>
<td>87.50</td>
<td>12.50</td>
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<tr>
<td>26</td>
<td>14</td>
<td>9</td>
<td>2</td>
<td>87.50</td>
<td>12.50</td>
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<td>0</td>
<td>83.33</td>
<td>16.67</td>
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<tr>
<td>28</td>
<td>21</td>
<td>4</td>
<td>0</td>
<td>84.00</td>
<td>16.00</td>
</tr>
<tr>
<td>29</td>
<td>19</td>
<td>4</td>
<td>0</td>
<td>82.61</td>
<td>17.39</td>
</tr>
<tr>
<td>30</td>
<td>19</td>
<td>4</td>
<td>0</td>
<td>82.61</td>
<td>17.39</td>
</tr>
<tr>
<td>31</td>
<td>19</td>
<td>3</td>
<td>4</td>
<td>82.61</td>
<td>17.39</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td>89.08</td>
<td>10.92</td>
</tr>
</tbody>
</table>

 Average 89.08 10.92 13.16 1.12
Did the package meet its objectives?

From the combined scores of groups A and B, Table X, it can be seen that in excess of 84% of the sample achieved greater than 80% of the objectives. This surpasses the pre-defined criterion of acceptable performance and thus the package can be said to have met its objectives.

**TABLE X**

<table>
<thead>
<tr>
<th>Percentage of Correct Answers</th>
<th>Percentage of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.38% scored 100%</td>
<td></td>
</tr>
<tr>
<td>26.92% scored 95% or more</td>
<td></td>
</tr>
<tr>
<td>57.69% scored 90% or more</td>
<td></td>
</tr>
<tr>
<td>65.38% scored 85% or more</td>
<td></td>
</tr>
<tr>
<td>84.61% scored 80% or more</td>
<td></td>
</tr>
<tr>
<td>15.39% scored less than 80%</td>
<td></td>
</tr>
</tbody>
</table>

1Criterion for acceptable performance was 80% of the students achieving 80% of the objectives.
Effect of Pre-test on Post-test performance

An F-test was performed in order to investigate possible differences between the means of the two group's post-test scores. With the mean for Group A (exposed to pre-test) 27.15, and the mean for Group B (not exposed to pre-test) equal to 27.86 no significant difference was established. The F-test score was 0.94. With df of 1, 51' an F-score greater than 4.03 was required for significance at c=0.05.

From this it can be seen that exposure to the pre-test has no significant effect on post-test performance.

Effect of previous (or concurrent) biology

A biserial correlation between exposure to high school biology (either previous or concurrent) and test scores was calculated for both the pre-test and the post-test.

A high correlation on the pre-test was not matched by the post-test. From this the conclusion can be drawn that exposure to high school biology was perhaps instrumental in the attainment of high pre-test scores.
but that it had no effect on, or relationship to, final achievement scores.

TABLE XI

BISERIAL CORRELATION BETWEEN EXPOSURE TO HIGH SCHOOL BIOLOGY AND TEST SCORES

<table>
<thead>
<tr>
<th></th>
<th>Pre-test $r_{bis}$</th>
<th>Post-test $r_{bis}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.94</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Attitude towards the instructional package

On completion of the post-test all subjects were asked to rate both the instructional package and their physical education programme in general. The ratings were made on a five point scale with 'like a great deal' scoring 4 points and 'dislike a great deal' scoring zero. 'Like a little' and 'dislike a little' scored 3 and 1 respectively with 'no feeling' neutral at a score of 2.

The mean score for the package was 3.46 compared to 3.61 for physical education in general. Using a

'It should be noted that for relatively small groups, and certain variations of normal distribution $r_{bis}$ can exceed 1.00. Thus $r_{bis}$ is not directly comparable to other correlation scores.'
t-test for dependant samples a t-score of 0.83 was obtained. With df=52 a t-score of 2.83 was required at α=0.05. Thus it can be said that the attitude towards the instructional package was highly positive but not significantly different from the student's attitude towards physical education in general.

Discussion

From the data presented and the statistical tests performed it can be seen that overall the package was successful in meeting its objectives and in teaching to a significant degree.

The administration of the pre-test had no significant effect on post-test performance, and thus, in wider usage can be included or excluded at the teacher's discretion.

Biological background at the high school level was shown to be significantly related to pre-test scores but unrelated to post-test scores. Thus the package would appear to negate the effect of differing biological backgrounds.

Attitude towards the package was shown to be positive and closely related to the students attitude towards physical education in general.
Weaknesses

Both the raw data and the success/failure indices indicate that objective IIc (tested by question 14) fell short of the accepted 80%-80% criteria for acceptable performance.

Thus a decision was made that information in this area be strengthened. This was achieved by the addition (noted △△ in the final amended draft of the instructional package - see Appendix E) of a specific statement and reminder on the summary page to the effect that the expired air is collected during the last minute of strenuous exercise.

It should be noted that this modification to the instructional package was not tested. It was felt, by the author, that the marginal nature of the weakness and the simplicity of the added material made re-testing of the whole package superfluous.
CHAPTER VII
PROPOSED IMPLEMENTATION

Dissemination of the instructional package to Newfoundland schools will be undertaken in two separate ways. In the first instance the material will be available through the Resource Clearinghouse of the Division of Learning Resources, Memorial University of Newfoundland. In this situation the Clearinghouse will hold master copies of the booklet which individual schools will be permitted to duplicate at their own cost. This is seen as an interim, stop-gap, solution to the distribution problem.

Final, large scale, distribution is contingent upon the acceptance of the booklet, as a required text supplement, by the Provincial Physical Education Curriculum Committee. It is proposed that the instructional package be submitted to the committee no later than its Spring session 1979. Before submission it is hoped to have the booklet master pages re-made with type set written material replacing the current typewritten
sections. This would allow the same information to be presented in a clearer, neater manner. No additional changes to the material are anticipated.


QUESTIONNAIRE

Within the APPLIED PHYSIOLOGY area of the Grade X Credit physical education programme there are many areas which required additional instructional materials. Please select the three areas, from those listed below, which YOU feel are MOST in need of additional instructional material.

When you have decided on the three which you feel need attention please rank the 1st, 2nd & 3rd in need.

<table>
<thead>
<tr>
<th>Area</th>
<th>Rank (three only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function of the heart.</td>
<td></td>
</tr>
<tr>
<td>Function of the lungs</td>
<td></td>
</tr>
<tr>
<td>Function of muscles</td>
<td></td>
</tr>
<tr>
<td>Function of blood</td>
<td></td>
</tr>
<tr>
<td>Measurement of fitness.</td>
<td></td>
</tr>
<tr>
<td>Maximum oxygen uptake Testing</td>
<td></td>
</tr>
<tr>
<td>Measurement of strength.</td>
<td></td>
</tr>
<tr>
<td>Measurement of flexibility.</td>
<td></td>
</tr>
<tr>
<td>Long Term effects of exercise</td>
<td></td>
</tr>
</tbody>
</table>
QUESTIONNAIRE

Now obviously an instructional package can be produced in a variety of ways. Some of the media which can be used are such things as slides, filmstrips, audio tapes or student booklets. Not all of the media are as effective as each other and certainly they are not all equally practical for classroom use. To ensure that the instructional package is produced in such a way that it will be of the greatest use to the greatest number of people, I would seek you help in deciding the media in which it will be produced.

Listed below are several of the media which it is practical for me to produce. For each medium I would like you to give TWO ratings. The first rating concerns how effective you think that particular medium is. For instance you might think that student booklets are a very effective way of presenting information while video-tapes are ineffective. Thus on the scales below you would indicate very effective with 1 and ineffective with 3.

The second rating concerns how practical you think the medium would be for YOU in YOUR SCHOOL. Thus if you have no video-tape player you would rate video-tapes as impracticable (3).

<table>
<thead>
<tr>
<th>Media</th>
<th>Effective — Ineffective</th>
<th>Practical — Impracticable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio tapes</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>Slides</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>Filmstrips</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>Video-tapes</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>Booklet only</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>Slide + tape</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>Slide + script</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>Filmstrip + Tape</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>Filmstrip + Script</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>Booklet + slide + script</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>Booklet + filmstrip + script</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
</tbody>
</table>
Having given thought to the various media and their ratings please think of the three most desirable forms of instructional package and rank them first, second and third.

1. Most desirable form of package

2. Next

3. Next

Thank You.
Appendix C

Questionnaire to obtain bibliographic data

The following questionnaire was used.

a. What is your age in years and months? ___ yrs ___ mo.
b. Sex? male Female (please circle one).
c. Are you now taking, or have you ever taken, a high school biology course? Yes No (please circle one)
d. Which of the following expresses how you felt about working through the booklet today?
   - liked a great deal
   - liked a little
   - no feeling
   - disliked a little
   - disliked a great deal Please tick one

e. Which of the following expresses how you feel about physical education classes in general?
   - like a great deal
   - like a little
   - no feeling
   - dislike a little
   - dislike a great deal Please tick one
Appendix D

The Test Instrument

The following test instrument was used as both the pre-test and the post-test. Each question is listed with the objectives tested by it.
<table>
<thead>
<tr>
<th>Objective Tested.</th>
<th>Question Number</th>
<th>Question</th>
</tr>
</thead>
</table>
| I-j              | 1                | The major function of the lungs is to extract oxygen from the _____.
| I-k              | 2                | The oxygen is able to pass through the wall of the alveoli into the _____.
| I-1.m.n.         | 3                | However fast blood flows through the lungs it always arrives containing _____ oxygen and leaves containing _____ oxygen.
| I-o              | 4                | To produce energy muscles need _____ and _____.
| I-q              | 5                | Usually when a muscle stops working it is because it does not have enough _____.
| I-r              | 6                | The _____ pumps oxygen rich blood to the muscles.
| I-s.u.           | 7                | How much work a person can do depends on how much _____ _____ blood arrives at the muscles.
| I-v              | 8                | How much oxygen can be used by the body and how much oxygen rich blood the _____ can pump, is a measure of _____.
| I-w              | 9                | The maximum amount of oxygen that a person can use in one minute is called his /her _____.
| I-x.y.           | 10               | To get a Max. VO₂ score, the amount of oxygen used per minute is divided by the person's _____.
| I-z              | 11               | Which of the following is a Max. VO₂ score? a. 23 ml. O₂/kg/min b. 199 litres/kg/min c. 29 lbs. O₂/hr/m d. 106 cu.in/ml. |
Objective Tested  Question number

II-a  12 The following is a list of steps required to obtain a Max. VO₂ score. Read the list and then place the steps in the correct order. Put a 1 beside the first step, 2 beside the second step, etc.

1. Calculate how much oxygen the subject used in one minute.
2. Calculate how much oxygen the subject breathed in, in one minute.
3. Work the subject to exhaustion, collect the expired air for one minute.
4. Collect all of the equipment together.
5. Measure how much air was expired in one minute.
6. Weigh the subject. Divide the amount of oxygen used in one minute by the weight of the subject.
7. Calculate the amount of oxygen the subject breathed out in one minute.
8. Take a sample of the expired air and measure how much O₂ it contained.

II-b  13 Below is a list of eight measurements only FOUR of which are required to calculate a Max. VO₂ score. Place a cross through the letter in front of the four which are required.

a. Height
b. Weight
c. Sex
d. Age
<table>
<thead>
<tr>
<th>Objective Tested</th>
<th>Question number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>13 (cont.)</td>
</tr>
<tr>
<td></td>
<td>e. Percentage of oxygen in air</td>
</tr>
<tr>
<td></td>
<td>f. Percentage of oxygen in expired air:</td>
</tr>
<tr>
<td></td>
<td>g. Volume of air expired.</td>
</tr>
<tr>
<td></td>
<td>h. Volume of oxygen in blood</td>
</tr>
<tr>
<td></td>
<td>II-c 14 Measurement of Max. VO₂ should be made</td>
</tr>
<tr>
<td></td>
<td>a. Immediately after the person stops exercising.</td>
</tr>
<tr>
<td></td>
<td>b. One minute after the person stops exercising</td>
</tr>
<tr>
<td></td>
<td>c. One minute before the person stops exercising</td>
</tr>
<tr>
<td></td>
<td>III-a 15 Calculate the Max. VO₂ score for the following person. He exhales 100,000 ml of oxygen in one minute. The INHALED air contained 21% oxygen and the EXHALED gas contained 15% oxygen. The person weighs 100 Kg. N.B The formula is given.</td>
</tr>
<tr>
<td></td>
<td>Max. VO₂ = _____ ml. O₂/kg/min.</td>
</tr>
<tr>
<td></td>
<td>IV-a 16 On a Max. VO₂ test people get these scores: Bob-82, Bill-91, Chris-55, Ron-29, Eric-36 and John-63. Describe them as exceptionally fit, very fit desirable fit, fair fitness or low fitness.</td>
</tr>
<tr>
<td></td>
<td>Bill is _______</td>
</tr>
<tr>
<td></td>
<td>Bob is _______</td>
</tr>
<tr>
<td></td>
<td>Chris is _______</td>
</tr>
<tr>
<td></td>
<td>Ron is _______</td>
</tr>
<tr>
<td></td>
<td>Eric is _______</td>
</tr>
<tr>
<td></td>
<td>John is _______</td>
</tr>
<tr>
<td>Objective Tested</td>
<td>Question number</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>V-a</td>
<td>17</td>
</tr>
<tr>
<td>I-p</td>
<td>18</td>
</tr>
<tr>
<td>I-t</td>
<td>19</td>
</tr>
<tr>
<td>V-c</td>
<td>20</td>
</tr>
<tr>
<td>V-b</td>
<td>21</td>
</tr>
<tr>
<td>V-d</td>
<td>22</td>
</tr>
<tr>
<td>V-f</td>
<td>23</td>
</tr>
<tr>
<td>I a-h</td>
<td>24-31</td>
</tr>
</tbody>
</table>
Match the letter with its correct name.

Capillary
Artery
Trachea
Alveoli
Bronchiole
Vein
Heart
Bronchus
It should be noted that the teacher's manual contains the student's manual in its complete and final form. Thus only the teachers manual is included here.
Measuring Fitness

by

Colin Higgs
Using the booklet

The student booklet, "Measuring Fitness", was designed written and field tested as a self-instructional manual. An integral part of the self-instruction is the set of questions which appear throughout the booklet. Students should be encouraged to WRITE IN THEIR ANSWERS TO THESE QUESTIONS as this reinforces the learning process.

While all of the material within the student manual can be covered by the student at one sitting of approx. 80 minutes it need not be. If the theory portion of the credit programme is covered during 40 minute periods it is suggested that the booklet be used for three periods:

i. The biological background

ii. The test procedures

iii. Interpretation of test scores/alternate tests.

The role of the teacher

The booklet was field tested in situations in which the teacher played no role in the learning process. Thus the teacher is free to aid those students who are having difficulty with the material. In field testing of the booklet approximately 90% of the students attained 90% of the stated objectives. The objectives are listed in Appendix A.

Follow-up activities

Some follow-up activities are listed in Appendix B

Additional references

Any teacher working in this field is encouraged to read (or re-read) Astrand's, "Textbook of Work Physiology", which is probably the best single reference text. Others are listed in Appendix C
Measuring Fitness

by

Colin Higgs
Measuring Fitness
@1978

by
Colin Higgs

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In conjunction with
Division of Learning Resources:
Faculty of Education, Memorial
University of Newfoundland
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Introduction
HOW DO YOU MEASURE FITNESS?

In the past, many different fitness tests have been tried. Some of the tests were quite good, but many gave very inconsistent results.

Recently one test has been developed which is excellent. It is called a

MAXIMUM OXYGEN UPTAKE TEST

What makes it a good test is that the people who ARE very fit always receive high scores and those who are less fit get lower scores. This means that it is an accurate fitness test. A second thing which makes it a good test is that it is reliable. By this it means that if a person takes the test twice (say about a week apart) he or she will get almost the same score both times.

UNDERSTANDING THE MAXIMUM OXYGEN UPTAKE TEST

To understand how the maximum oxygen uptake test works you have to know something about how the body gets the energy it needs to make the muscles work.

Some of you, especially if you have done biology, will know a lot of this material already. If you do, that's great. If you don't then work your way through and try answering the questions at the end of each section. If you get the answers right continue on, if you don't then go over the material again. If you still have need of help after that, see your teacher.

This booklet is divided into two sections:

i. The biological background to the maximum oxygen uptake test.

ii. The maximum oxygen uptake test—How it is performed & how the scores are calculated.
HOW THE LUNGS WORK

We are all surrounded by air all of our lives. The air is made up of several different gases. These are:

\[
\begin{align*}
O_2 & \quad \text{Oxygen} \\
N & \quad \text{Nitrogen} \\
CO_2 & \quad \text{Carbon dioxide}
\end{align*}
\]

The inhaled nitrogen and carbon dioxide are not used by the body and are therefore of little importance.

It is the OXYGEN that is very important and which keeps us alive. The function of the lungs is TO EXTRACT OXYGEN FROM THE AIR

The oxygen which is extracted (that means taken out of) the air is used by the body to keep us alive.

Getting the air into the lungs

When we breathe in we suck air (containing \(O_2\), \(N_2\) & \(CO_2\)) into the lungs. This is called inspiration.

Air, including oxygen, enters the body through the nose or mouth

Breathing out is called expiration.
QUESTIONS

Now that you have looked at the diagram see if you can answer the following questions:

1. How does air enter the body? Through the ___________ and ___________.

2. What is the chemical symbol for:
   a. Oxygen ___________
   b. Nitrogen ___________
   c. Carbon dioxide ___________

3. The function of the lungs is to ___________ oxygen from the air.

4. Do we use nitrogen in our bodies? Yes  No
   Do we use carbon dioxide in our bodies? Yes  No
   Do we use oxygen in our bodies? Yes  No

Now turn the page upside down and check your answers. If you have any wrong turn back to the previous page. If you still have trouble see your teacher.
Getting OXYGEN into the blood

1. Air, containing oxygen (O₂), is sucked into the lungs. The oxygen passes down through the TRACHEA (a) and then through the BRONCHUS (b) into the smaller tubes of the lungs.

2. The oxygen continues down through the small BRONCHOLES (c) and then reaches the air sacs or ALVEOLI (d).

3. The oxygen passes through the wall of the alveoli through the wall of the CAPILLARY (e) and into the blood flowing through the capillary.
QUESTIONS

Now that you have looked at the diagram, see if you can answer the following questions:

1. What are the following parts of the lung called?

2. The oxygen goes through the wall of the alveoli and into the

3. The blood flows through

Now turn the page upside down and check your answers. If you have any wrong, turn back to the diagram on the previous page. If you still have trouble, see your teacher.

Answers:
How BLOOD carries OXYGEN

1. The oxygen goes through the wall of the alveoli and into the blood where it is carried by the red blood cells (R.B.C's).

2. The red blood cells are disc shaped, thinner in the middle than at the edges.

3. The heart pumps the blood, with the oxygen carrying R.B.C's, throughout the body. The harder and faster the heart pumps, the faster the blood flows through the lungs and the rest of the body.

4. The blood enters the lungs carrying little oxygen and leaves full of oxygen.

5. Regardless of how fit you are and how fast the blood flows through the lungs, the blood always leaves full of oxygen.
QUESTIONS

Now that you have looked at the diagram see if you can answer the following questions.

1. What do the letters R.B.C. stand for.
2. Draw a top view and a side view of a red blood cell.
3. The blood arrives at the alveoli containing ______ oxygen.
4. If the blood is flowing through the alveoli at full speed it leaves ______ of oxygen.
5. The _____ pumps the blood around the body.
6. The harder and faster the heart beats, the ______ the blood flows around the body and through the lungs.

Now turn the page upside down and see if you had the correct answers. If not turn back to the diagram and go over it again. If you still have trouble see your teacher.
Getting OXYGEN to the MUSCLES

1. **THE LUNGS**
   - EXTRACT OXYGEN FROM THE AIR
   - The oxygen passes through the ALVEOLI into the blood flowing through the CAPILLARIES.

2. **THE HEART**
   - PUMPS THE BLOOD AROUND THE BODY
   - The heart pumps the blood to the lungs to pick up the oxygen and then it pumps the blood to all of the muscles of the body where the oxygen is used.

3. **THE MUSCLES**
   - USE THE OXYGEN CARRIED BY THE BLOOD
   - They use the oxygen to provide the energy needed to do work - such as lifting, running or playing soccer.
QUESTIONS

Now that you have looked at the diagram see if you can answer the following questions:

1. The ______ pumps the blood around the body.

2. The heart pumps blood to the ______ to pick up oxygen and to the muscles where the oxygen is used to provide ______.

3. Arteries carry blood ______ the heart.

4. Veins carry blood ______ the heart.

5. Now turn the page upside down and check your answers. If you have any wrong turn back to the diagram and go over it again. If you still have trouble then see your teacher.
USING the OXYGEN

FOR A MUSCLE TO WORK IT NEEDS TWO THINGS:
(a) FOOD - USUALLY A SUGAR CALLED GLUCOSE
(b) OXYGEN.
THE MUSCLE CONTAINS ENOUGH GLUCOSE TO WORK HARD FOR A LONG TIME.

HOW HARD IT DOES WORK DEPENDS ON HOW MUCH OXYGEN THE MUSCLE CAN GET. THIS DEPENDS ON HOW MUCH OXYGEN RICH BLOOD IS PUMPED TO IT.

NOW REMEMBER

A. THE BLOOD LEAVING THE LUNGS IS ALWAYS FULL OF OXYGEN
B. THE MUSCLES WILL USE ALL OF THE OXYGEN THEY CAN GET WHEN THEY ARE WORKING HARD
C. HOW HARD THE MUSCLE IS ABLE TO WORK DEPENDS ON HOW MUCH BLOOD THE HEART CAN PUMP TO THE MUSCLES
D. THE MORE BLOOD THAT IS PUMPED TO THE MUSCLES THE MORE OXYGEN THE BODY USES.

HOW MUCH OXYGEN CAN BE USED IS A MEASURE OF HOW MUCH BLOOD THE HEART CAN PUMP. THIS IN TURN IS THE BEST MEASURE OF A PERSON'S FITNESS. TO MEASURE FITNESS THIS WAY THE MAXIMUM AMOUNT OF OXYGEN WHICH A PERSON CAN USE IN ONE MINUTE IS FOUND.

THE MAXIMUM AMOUNT OF OXYGEN THAT THE BODY CAN USE IN ONE MINUTE IS CALLED

MAXIMUM OXYGEN UPTAKE
QUESTIONS

Now that you have looked at the diagram see if you can answer the questions.

1. To do work the muscles need. a.  
   b.  

2. How hard the muscles are able to work depends on how much they can get.

3. How much oxygen the body can use is a measure of how much the heart can pump.

4. The amount of blood that the heart can pump in a minute is a measure of a person's  

5. The amount of oxygen the body can use in one minute is called  

Now turn the page upside down and check the answers. If you have any wrong turn back to the previous diagram and go over it again. If you are still having trouble see your teacher.
The Maximum Oxygen Uptake Test

A test of maximum oxygen uptake is used to measure fitness. It is called the maximum oxygen uptake test. The score that a person gets on the test is called his or her Max. \( \dot{V}O_2 \).

The maximum oxygen uptake test measures the amount of oxygen that a person is able to use when they are working as hard as possible. It is a good measure of fitness because it directly measures how hard the person is able to work his muscles.

How do we do a maximum oxygen uptake test? Let us look at the procedure.

STEP ONE

Get all the equipment together that will be needed. The equipment required is:

1. A BICYCLE ERGOMETER. This is a piece of equipment which is like an exercise bike. It has a saddle and pedals like a normal bike but when the pedals are turned instead of going along the bike stays still and a large, heavy, wheel is turned. There is a brake on the wheel which can be tightened to make it harder and harder for the person to pedal. In this way it is possible to control just how much work a person does.

2. DOUGLAS BAGS. These are just large bags in which all of the air that a person expires is collected. To collect the gas the person breathes in and out through a mouth-piece which allows the outside air to be breathed in but which makes all of the expired air go into the collection bag.

3. AN OXYGEN ANALYSER. This is a piece of equipment which measures how much oxygen there is in a sample of air. If we put ordinary air into it we get a reading of about 21%. If we put expired air into it we get a reading somewhere between 12% and 18%. This instrument allows us to measure how much of the inspired oxygen has been used. If the inspired air has the normal 21% oxygen and the expired air has 16% oxygen then the person being measured has used 5%. In general the harder a person is working the more oxygen they will use and the lower the percentage of oxygen in their expired air.

4. A GAS MEASURER. This instrument measures how much gas is collected in the Douglas bags. The amount of gas is measured in millilitres which is abbreviated ml.
STEP TWO

The person rides the bicycle ergometer and every minute the brake is tightened so that he has to work harder. Just before he collapses from exhaustion the air that he expires is collected for ONE MINUTE. It is often difficult to judge exactly when a person approaches exhaustion. Sometimes the expired gas is collected every minute until the person stops.

STEP THREE

A small sample of the expired air is taken from the DOUGLAS bag and is put into the oxygen analyser. A measurement is taken from the scale of the analyser. The measurement is usually between 12 and 18%. For an example of how the calculations are done let us say that the measurement was 16%.

Small sample of expired air is taken from the Douglas Bag and is put into the oxygen analyser. This measures the percentage of oxygen in the expired air.
STEP FOUR

The expired air is then forced through the gas measurer and the volume of the expired air is measured. As an example let us say that the person expired 90,000 ml of air.

![Diagram of Douglas Bag and Measuring Instrument]

The Douglas bag is rolled up to force the expired air through the measuring instrument.

STEP FIVE

Calculate how much oxygen the subject breathed in.

To do this we use the following formula:

\[
\text{VOLUME OF } O_2 \text{ BREATHED IN} = (\text{Volume of expired gas} \times 21)\%.
\]

*This is because the air that is breathed in contains 21% oxygen.

For our example this is

\[
\text{VOLUME OF } O_2 \text{ BREATHED IN} = 90,000 \times \frac{21}{100}
\]

\[
= 18900 \text{ ml of oxygen.}
\]

This is the amount of oxygen breathed in during one minute.
STEP SIX

calculate how much oxygen the subject breathed out during the minute that the gas was collected. To do this we use the formula:

\[
\text{VOLUME OF } O_2 \text{ BREATHED OUT} = (\text{Volume of expired air}) \times (\text{the percentage of oxygen in the expired air})
\]

For our example this is

\[
\text{VOLUME OF } O_2 \text{ BREATHED OUT} = 90,000 \times \frac{16}{100} = 14400 \text{ ml of oxygen.}
\]

STEP SEVEN

Calculate the amount of oxygen used in the minute that the gas was collected.

\[
\text{OXYGEN USED} = (\text{OXYGEN BREATHED IN} - \text{OXYGEN BREATHED OUT})
\]

For our example this is

\[
\text{OXYGEN USED} = 18900 - 14400 = 4500 \text{ ml of oxygen in one minute}
\]
Different size animals need different amounts of oxygen to do the same amount of work.

Because of this there is a need to adjust the maximum oxygen uptake score to reflect the different sizes of the people who are tested. The easiest way to do this is to work out how much oxygen was used during the minute by every kilogram of the subject's body. To do this the subject is weighed and the amount of oxygen he used is divided by his weight in kilograms.

\[
\text{Max. } \text{VO}_2 = \frac{\text{(amount of oxygen used in one minute)}}{\text{weight of the subject}}
\]

For our example: if the subject weighs 73 kg,

\[
\text{Max. } \text{VO}_2 = \frac{4500 \, \text{ml O}_2/\text{min}}{73 \, \text{kg}} = \frac{61.64 \, \text{ml O}_2/\text{kg/min}}
\]
SUMMARY OF STEPS

1. COLLECT ALL OF THE EQUIPMENT

2. WORK THE SUBJECT TO EXHAUSTION, COLLECT EXPIRED AIR FOR ONE MINUTE.

3. TAKE A SAMPLE OF THE EXPIRED AIR AND MEASURE HOW MUCH OXYGEN IT CONTAINS

4. MEASURE HOW MUCH AIR WAS EXPIRED IN THE ONE MINUTE.

5. CALCULATE HOW MUCH OXYGEN THE SUBJECT BREATHED IN DURING THE ONE MINUTE.

6. CALCULATE HOW MUCH OXYGEN THE SUBJECT BREATHED OUT IN THE ONE MINUTE.

7. CALCULATE HOW MUCH OXYGEN THE SUBJECT USED IN THE ONE MINUTE.

8. WEIGH THE SUBJECT, DIVIDE THE AMOUNT OF OXYGEN USED IN THE ONE MINUTE BY THE WEIGHT OF THE SUBJECT.

   RESULT GIVES $\text{Max. VO}_2$ IN ml of $O_2$/min/kg.

9. REMEMBER - THE EXPIRED AIR IS COLLECTED DURING THE Last MINUTE OF EXERCISE.
A SAMPLE CALCULATION

To calculate a Max. VO₂ score there are **FOUR** things which you need to know.

1. Volume of expired air for one minute's exercise. In the formula this is called VE. e.g. 60,000 ml
2. The percentage of oxygen in the INSPIRED AIR. Called %-Insp. e.g. 21%
3. The percentage of oxygen in the EXPIRED AIR. Called %-Exp. e.g. 17%
4. The weight of the person in kilograms. Called wt. e.g. 63kg.

THE FORMULA

\[
\text{Max. VO}_2 = \frac{(VE \times \%\text{-Insp})}{100} \frac{(VE \times \%\text{-Exp})}{100} \frac{\text{wt}}{\text{wt}}
\]

USING THE FIGURES ABOVE

\[
\text{Max. VO}_2 = \frac{(60,000 \times 21)}{100} \frac{(60,000 \times 17)}{100} \frac{63}{63}
\]
\[
= \frac{12600}{63} - \frac{10200}{63}
\]
\[
= 38.1 \text{ ml.O}_2/\text{kg/min}
\]
THE WHOLE SYSTEM

THE LUNGS

The lungs extract oxygen (O₂) from the air.

The oxygen enters the lungs and reaches the alveoli where it passes through the wall of the alveoli and into the blood. In the blood the O₂ is carried by the red blood cells. The blood goes to the heart and is then pumped to all other parts of the body.

THE HEART

The heart acts as a pump to push the oxygen-rich blood through the blood vessels to the muscles which are working.

The more fit you are, the more blood the heart can pump to the muscles and the more work they can do.

The maximum amount of oxygen which the muscles use depends on how much oxygen-rich blood the heart can pump to the muscles.

Because of this, the amount of oxygen used by the body during very strenuous exercise is a good measure of the fitness of the heart.

The amount of oxygen a person can use during a minute of exhaustive exercise is called his or her maximum oxygen uptake.

This amount of oxygen divided by the person's weight (in kg) is called his or her Max. Ω uptake.

It is measured in ml of O₂/min/kg

THE MUSCLES

The muscles need oxygen so that they can combine it with food to produce energy.

This energy is used to perform all types of muscular work.

The more oxygen that is available the harder the muscles are able to work.

Because of this the amount of oxygen that the body can use in one minute is a good measure of fitness.
USING FITNESS SCORES

Fitness scores are of great use in a fitness program as they allow a person to measure the effectiveness of a long term series of exercises.

For example let us look at the scores of a student. Bill G. was tested for his Max. VO₂ at the start of the school year. His scores were:

i. In one minute he expired 87,000 ml of gas.
ii. Inspired air contained 21% oxygen.
iii. Expired air contained 18% oxygen.
iv. His weight was 62 kg.

CALCULATE HIS Max. VO₂.

Bill's starting Max. VO₂ was ................ ml. O₂/kg/min

At the end of 12 weeks of regular jogging he was tested again. This time his scores were:

i. In one minute he expired 85,000 ml of gas.
ii. Inspired air contained 21% oxygen.
iii. Expired air contained 16% oxygen.
iv. His weight was 60 kg.

CALCULATE HIS NEW Max. VO₂.

Bill's final Max. VO₂ was ................ ml. O₂/kg/min

Check your Max. VO₂ scores, they are printed at the bottom of the next page.

As you can see, Bill improved his fitness over the twelve week period. By regularly retesting it will be possible for Bill to MEASURE if he is getting fitter, or less fit.
INTERPRETING FITNESS SCORES

Over a twelve week period Bill increased his Max. VO₂ from 42.1 to 56.6 ml. O₂/kg/min. What does this mean in terms of how fit he is? How does he compare with other people?

The chart below shows the kind of scores which have been recorded by different groups of people.

As you can see, Bill went from a level of fitness which would be described as FAIR to having a desirable level of fitness.
Some Problems

Although the MAXIMUM OXYGEN UPTAKE TEST is the best way to measure a person's fitness it does have a few problems. For one thing it is very hard work and not many people are willing to work until they are exhausted and if they give up before they are exhausted they do not get as high a score as they should.

Then there is the problem of all of the expensive equipment that is needed to measure the percentage of oxygen in the air, and lastly there is the problem that for some people a Max. VO₂ test can be dangerous. At least one person has died during the test because they had a weak heart which could not stand the strain. Because of this anyone doing a test to exhaustion should have a complete medical examination before they start.

Because of these problems some other tests have been invented in which AN ESTIMATE of maximum oxygen uptake is made from a person's score on a non-exhaustive test. These tests are called sub-maximal tests.

The best of these sub-maximal tests is the ASTRAND bicycle ergometer test.

In the Astrand bicycle ergometer test the brake on the ergometer is set at a certain level, usually between 14 and 5 kpm. The rider peddles with 50 revolutions per minute for about 4 minutes. During the last minute of the ride the person's heart rate (pulse rate) is taken.

The chart on the next page is used to calculate the maximum oxygen uptake.

TO USE THE CHART. Place a straight edge on the line on the right of the page at the level which is the same as the reading of the bicycle ergometer brake.

Place the other end of the straight edge on the line to the left at the level of the pulse rate which was recorded.

Where the straight edge cuts the MAXIMUM OXYGEN UPTAKE line read off the amount of oxygen which the person COULD USE if they worked to exhaustion.

(Many people find it easier to use the BOTTOM edge of a ruler to read off the maximum oxygen uptake rather than the top edge.)

REMEMBER

1. The amount of oxygen must be divided by the person's weight to get a Max. VO₂ score.

2. There are separate charts for males and females.
**This Nomogram can be used to predict Max. VO₂ for women. It is to be used with a MONARCH bicycle ergometer on which the rider peddles at 50 revolutions/min. The pulse rate is to be taken after the rider has been working for FOUR (4) minutes. The "oxygen used" shows the amount of oxygen used by the rider in ONE MINUTE, IF THEY WERE WORKING AT THEIR MAXIMUM. To calculate the Max. VO₂, that amount of oxygen should be divided by the rider's body weight in kg. This will give the rider's maximum oxygen uptake in ml O₂/kg/min.**
**This nomogram can be used to predict Max. $V_O_2$ for men. All other details are the same as for the women's nomogram.**
If there is no bicycle ergometer available there are other, less accurate, methods of measuring fitness. Some of the more common fitness tests which are used in schools are:

a. The Canada Home Fitness Test.
b. The Cooper 12 minute run.
c. The Harvard Step Test.

These, and many others, are good tests of fitness. However, none of them is as accurate as either the complete maximum oxygen uptake test or the Astrand estimate of maximum oxygen uptake.
APPENDIX A

These were the objectives which the instructional package was designed to meet. Also included are the questions which were used to test the objectives.
Behavioural Objectives

All behavioural objectives were constructed such that they were suitable for testing using pencil and paper tests. The five sub-sets of objectives represent one sub-set for each of the sub-packages with one sub-set for the overall instructional package.

Sub-set I

a-h. That given a diagram of the heart and lungs along with the names of the anatomical parts the student will be able to match the names of the parts with 80% accuracy. The parts concerned were: a-heart, b-veins, c-arteries, d-trachea, e-bronchus, f-bronchiole, g-alveoli and h-capillary.

j-z. That in an objective test the student will be able to correctly answer 80% of the questions covering the following material.

j. The function of the lungs is to extract oxygen from the air.

k. That the oxygen passes through the walls of the lungs and into the capillary (blood).

l. That the blood entering the lungs contains very little oxygen.
m. That the blood leaving the lungs is full of oxygen.

n. That however fast the blood flows through the lungs it leaves full of oxygen.

o. That muscles need food and oxygen to produce energy.

p. That the harder a person works the more oxygen he uses.

q. That if the muscles do not get the oxygen they need they are forced to stop working.

r. That the heart pumps oxygen rich blood to the muscles.

s. That how much blood the heart is able to pump will determine how hard a person can work.

t. That there is a limit to how much oxygen rich blood the heart is able to pump per minute.

u. That the amount of oxygen rich blood which arrives at the muscles determines how much work a person can do.

v. That the maximum amount of oxygen a person can use per minute is a measure of how fit he is.
w. That the maximum amount of oxygen a person can use is called his maximum oxygen uptake.

x. That different size people need different amounts of oxygen to do the same amount of work.

y. That to get a Max. VO₂ score the amount of oxygen used in a minute is divided by the subject's weight.

z. That Max. VO₂ is measured in ml. O₂/kg/min.

Sub-set II

a. That given a list of all of the steps in the performance of a maximum oxygen uptake test the student will be able to place them in the correct order.

b. That the student will be able to identify the four essential measurements which must be made to obtain a Max. VO₂ score.

c. That the student will identify that Max. VO₂ measurements are made in the last minute of strenuous exercise.

Sub-set III

a. That given the amount of gas exhaled per minute, the percentage of oxygen in that gas, the oxygen content
of inspired air and the weight of the subject, the student will be able to calculate a Max. VO₂ score. The formula for the calculation will be given.

Sub-set IV

a. That given a set of Max. VO₂ scores the student will be able to place them in categories of excellent, desirable, fair and poor fitness levels with 80% accuracy.

Sub-set V

a. That the student will be able to state that the maximum oxygen uptake test is the best available measure of physical fitness.

b. That the maximum oxygen uptake test is a measure of how well the body can extract oxygen from the air.

c. That the maximum oxygen uptake test is a measure of the heart's ability to pump blood.

d. That most other fitness tests are only estimates of maximum oxygen uptake.

e. That the maximum oxygen uptake test is a very strenuous test that should only be performed after the subject has had a medical examination.
f. That Max. VO₂ scores can be improved by training.

* N.B. All objectives are referred to by their sub-section Roman numeral and by their letter. That is Vₑ.
### Test Items

<table>
<thead>
<tr>
<th>Objective Tested</th>
<th>Question Number</th>
</tr>
</thead>
</table>
| I-j              | 1               | The major function of the lungs is to extract oxygen from the _____.
| I-k              | 2               | The oxygen is able to pass through the wall of the alveoli into the _____.
| I-l.m.n.         | 3               | However fast blood flows through the lungs it always arrives containing _______ oxygen and leaves containing _______ oxygen.
| I-o              | 4               | To produce energy muscles need _______ and _______.
| I-q              | 5               | Usually when a muscle stops working it is because it does not have enough _______.
| I-r              | 6               | The _______ pumps oxygen rich blood to the muscles.
| I-s.u.           | 7               | How much work a person can do depends on how much _______ blood arrives at the muscles.
| I-v              | 8               | How much oxygen can be used by the body and how much oxygen rich blood the_______ can pump, is a measure of _______.
| I-w              | 9               | The maximum amount of oxygen that a person can use in one minute is called his /her _______.
| I-x.y.           | 10              | To get a Max. VO₂ score, the amount of oxygen used per minute is divided by the person's _______.
| I-z              | 11              | Which of the following is a Max. VO₂ score? a. 23 ml. Q₂/kg/min  b. 199 litres/kg/min c. 29 lbs. Q₂/hr/m  d. 106 cu.in/ml. |
The following is a list of steps required to obtain a Max. VO₂ score. Read the list and then place the steps in the correct order. Put a 1 beside the first step, 2 beside the second step, etc.

- Calculate how much oxygen the subject used in one minute.
- Calculate how much oxygen the subject breathed in, in one minute.
- Work the subject to exhaustion, collect the expired air for one minute.
- Collect all of the equipment together.
- Measure how much air was expired in one minute.
- Weigh the subject. Divide the amount of oxygen used in one minute by the weight of the subject.
- Calculate the amount of oxygen the subject breathed out in one minute.
- Take a sample of the expired air and measure how much O₂ it contained.

Below is a list of eight measurements only FOUR of which are required to calculate a Max. VO₂ score. Place a cross through the letter in front of the four which are required.

a. Height
b. Weight
c. Sex
d. Age
13 (cont.)

- Objective Tested Question number -

e. Percentage of oxygen in air
f. Percentage of oxygen in expired air.
g. Volume of air expired.
h. Volume of oxygen in blood.

II-c 14 Measurement of Max. VO₂ should be made

a. Immediately after the person stops exercising.
b. One minute after the person stops exercising
c. One minute before the person stops exercising.

III-a 15 Calculate the Max. VO₂ score for the following person. He exhales 100,000 ml of oxygen in one minute. The INHALED air contained 21% oxygen and the EXHALED gas contained 15% oxygen. The person weighs 100 Kg. N.B The formula is given.

Max. VO₂ = _______ ml. O₂/kg/min.

IV-a 16 On a Max. VO₂ test people get these scores: Bob-82, Bill-91, Chris-55 Ron-29, Eric-36 and John-63. Describe them as exceptionally fit, very fit desirable fit, fair fitness or low fitness.

Bill is __________________________
Bob is __________________________
Chris is __________________________
Ron is __________________________
Eric is __________________________
John is __________________________
Objective Tested | Question number | 
--- | --- | 
V-a 17 | The Max. VO_2 test is the most _____ test of physical fitness. | 
I-p 18 | The harder a person works the _____ oxygen he uses. | 
I-t 19 | Up to a limit, the harder a person works the more _____ blood the heart pumps per minute. | 
V-c 20 | The Max. VO_2 test is a measure of how well the body can extract _____ from the ____. | 
V-e 21 | The Max. VO_2 test is very _____ and should only be performed after the subject has had a _____ examination. | 
V-d 22 | Other fitness tests give an _____ of maximum oxygen uptake. | 
V-f 23 | A person who takes a Max. VO_2 test and then trains hard for three months would expect a _____ score at the end of the training period. | 
I a-h 24-31 | See diagrams on following page. |
APPENDIX B

Suggestions for follow up activities.
SUGGESTED FOLLOW UP ACTIVITIES

1. Test the class on two different fitness tests. Compare the results. Are the same people 'fit' or 'unfit' on both tests? If the results are not identical discuss which of the tests is likely to have given the best results.

2. Measure the fitness of a group of students on one of the fitness tests. Record the results and then re-test the students several weeks later. If this is done in conjunction with a fitness unit it can show the improvement which has been achieved. If it is done over the period of a vacation it may show some deterioration.

3. Have the students investigate as many other fitness tests as possible.

4. Have the students prepare reports on the following topics:
   a. Fitness scores of credit and non-credit programme students.
   b. Fitness levels of males and females.
   c. Fitness levels of varsity players as compared to intra-mural players.

5. Encourage the students to undertake a long-term periodic testing programme.
APPENDIX C

List of related references.

Without a doubt the finest current text book is,


Articles of interest are listed on the following pages in alphabetical order.


APPENDIX F

Content expert for the formative evaluation was:
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