COMPUTER-AIDED LEARNING IN DISADVANTAGED COMMUNITIES IN THE SOUTHERN CAPE AND KAROO — A NUTRITION EDUCATION INITIATIVE

I Venter, D Marais, R de Muynk, A Shedden

Objective. To evaluate the efficacy of a computer-aided learning (CAL) nutrition module.
Design. A pre-test/post-test (immediate and follow-up post-testing) design was used to evaluate the impact of the CAL nutrition module, using validated multiple-choice questionnaires. The module consisted of five interactive sub-modules each covering a single concept of nutrition (5 - 10 minutes in duration).
Setting and subjects. The total sample included 141 low-income Afrikaans-speaking clients with low literacy levels attending clinics involved in the literacy programme in the Southern Cape and Karoo.
Outcome measures. To evaluate the impact of the CAL nutrition module regarding knowledge, attitude and behaviour using differences between pre- and post-test scores. A one-tailed *z*-test for comparison of knowledge and attitude scores and a χ^2-test for responses to behaviour questionnaires were used for statistical analysis.
Results. The improvement in acquired and retained mean knowledge and attitude scores was highly significant ($P = 0.002$). Behaviour improved significantly and was retained for at least a month regarding more meals ($P = 0.005$), milk intake ($P = 0.005$) and legume intake ($P = 0.01$).
Conclusions. The use of the interactive CAL nutrition module resulted in knowledge being acquired and retained and positive changes in attitude and behaviour. This has led to it being translated into English and Xhosa as well as additional modules being added.

Department of Food and Consumer Sciences, Cape Technikon, Cape Town
Irma Venter, M Nutrition
Department of Human Nutrition, University of Stellenbosch and Tygerberg Hospital, Tygerberg, W Cape
Debbi Marais, M Nutrition
Directorate: Information and Technological Services, Western Cape Education Department, Cape Town
Rosalind de Muynk, MA (Linguistics)
Alastair Shedden, MA (Geography)

According to several studies, the computer is accepted as an instructional medium that may stimulate interest or motivation[1] and has become an important basic tool for education.[2] However, nutrition and health education have made limited use of this tool.[2] Computer-aided learning (CAL) is a learner-centred environment with the potential to increase both the effectiveness and efficiency of nutrition education and to improve student interest and learning retention.[2,3] Studies comparing CAL with traditional methods have found that it can be as effective or superior,[1,4-6] especially regarding a more positive attitude towards learning.[4] It promotes active, individualised learning[1,2,4] and many students have reported a preference for CAL because it is convenient and provides constant interaction[2] and feedback.

The advantages of this environment for the user are: progress is self-paced,[1,4] question-answer-feedback on performance is immediate,[1,4] it allows for ongoing self-evaluation, and the modules can be repeated as often as required, thus avoiding users becoming embarrassed in situations where they have poor comprehension and require repeated revision.[1] CAL can offer the opportunity to practise newly learned concepts in a non-threatening atmosphere.[4]

Advantages for the health personnel are that they are relieved of the task of endlessly repeating the same basic information and can therefore devote more time to the individual needs of clients.[1,4] Information can be standardised and free from biases such as facial expression and tone of voice.[1] Computers can also simulate experiences that would be difficult, expensive or impossible to duplicate in a learning environment and they can provide opportunity for practice so that learners gain competency in real-life situations.[1]

By using computers in nutrition education, the opportunity for better use of professional and client time is provided. Similarly, using computerised nutrition education programmes could be a productive use of the time that patients spend in waiting rooms. Here, clients could benefit from nutritional guidance even when qualified nutrition educators are not present. The decreasing cost of computers and the increasing cost of professionals' time makes computers practical today and likely to become even more practical in the future.[1]

In evaluating this programme, it was hypothesised that there would be no significant differences in knowledge, attitude and behaviour between the mean scores of the pre-test and immediate post-test, and the pre-test and follow-up post-test.

METHODS

A CAL nutrition module was developed in conjunction with the former Media Production Unit of the Department of Education and Culture, Administration: House of Representatives over a 9-month period using HyperCASE from

Interactive Image Technologies Ltd., Toronto, Canada (a multi-platform development tool for building interactive graphical applications). The content was based on learning materials developed by the Sub-Directorate: Nutrition, Department of Health and colleagues reviewed the drafts for content accuracy. The nutrition module used for testing covered 18 basic nutrition concepts grouped into five sub-modules (Table I). The subject matter was divided into small blocks of information which the client could master independently. The sub-modules are 5 - 10 minutes in duration, to allow for the possible short attention span of the users as well as the limited time they have available during clinic visits.

Presentation was in the context of real-life situations with polite and friendly language throughout and a vocabulary (concise and clear) targeted for the functionally literate. Full-colour graphics (line art developed using ZSoft's PC Paintbrush) are lavishly used to elucidate meaning. The approach is essentially linear with frequent testing of comprehension and consolidation of concepts using true/false and multiple choice questions together with a variety of interactive techniques such as graphical and text-based 'drag and drop'. Appropriate feedback is given with each answer (praise for a correct response and remediation for incorrect responses).

Clients did not have to be computer literate as only the ACTION and ENTER keys were used. Each client logged in using his/her name and a password. This password enabled the tracking of the learner and bookmarking. Clients worked at their own pace and started with a test programme to introduce them to the module and explain the workings of the keyboard. The client then chose which sub-module to start or continue with and could repeat any part as many times as desired.

To evaluate the impact of the CAL nutrition module regarding knowledge, attitude and behaviour the researchers used a pre-test/post-test design, using validated questionnaires (questionnaires were tested for face validity by a group of low-literacy level adults working in a health environment, and content validity was evaluated by dieticians). The questionnaires contained questions to test knowledge, attitude (cognitive, affective and conative aspects) and behaviour, with an equal number of questions on each of the main messages, i.e. regular meals, the three food groups, energy foods, protective foods and body-building foods. All three questionnaires were composed of the same 25-item, multiple-choice questions in the same order. A pre-test was administered to clients before starting. A post-test was completed immediately after completion of all the sub-modules (immediate post-test) and another post-test was administered to clients a month later (follow-up post-test).

Twelve clinics in the Southern Cape and Karoo area (Heidelberg, Riversdal, Albertinia, D'Almeida, Mossel Bay Ext. 23, Grootbrakrivier, Conville, Rosemore, Sedgefield, Hornlee, Kranshoek and Oudtshoorn) were involved. Clinic inclusion criteria were the presence of the Unisys ICON education computer system equipped with the AutoSkill Component Reading application and clinic personnel available to control the project. Clinic personnel were requested to recruit a convenience sample of a maximum of 50 clients who needed to know more about good nutrition and who could read simple Afrikaans. They had to register the clients on the computer for the use of the nutrition modules and ensure that they completed the necessary questionnaires. Clients needed to complete all the sub-modules and parts thereof (record keeping was by means of computer printouts). The nutrition module

Table I. Contents of the basic nutrition module

Sub-modules	Parts
1. Eat right, stay healthy	Part 1 – The importance of regular meals
	Part 2 – The three food groups
	Part 3 – The right food for good health
II. Energy foods	Part 1 – Why energy food is necessary for life
	Part 2 – Which foods are energy foods: cereals
	Part 3 – Which foods are energy foods: fats and oils
	Part 4 – Which foods are energy foods: sugar and sugar products
III. Body-building foods	Part 1 – Why body-building foods are necessary for life
	Part 2 – Which foods are body-building foods: milk and milk products
	Part 3 – Which foods are body-building foods: meat and legumes
IV. Protective foods	Part 1 – Why protective food is necessary for life
	Part 2 – What protective food is: how to save money
	Part 3 – How to cook protective food
V. What must I eat?	Part 1 – What nutrition is
	Part 1 – The functions of the food groups
	Part 3 – Which food belongs in each food group
	Part 4 – What a balanced meal and diet is
	Part 5 – Which foods are most healthy

was installed and the clinic personnel trained by the researchers (according to a standardised training manual). Each clinic was visited once during the data collection period to ensure compliance with the protocol.

RESULTS

All 12 clinics participated in the survey. Two hundred and fifty-one subjects were recruited, of whom 141 returned all three questionnaires, namely the pre-test, immediate post-test and follow-up test (indicating a fall-out rate of 43.8%). The mean age (± standard deviation (SD)) of the sample was 21 years (± 9.74 years) and subjects were predominantly female (86%). Two-thirds of the sample had some high school education and the rest, 33%, had primary school education. The total sample (N = 141) was sufficiently large to use the one-tailed z-test for comparison of the pre-, immediate post- and follow-up test item scores. In all of the items, the participants scored 1 for the 'correct' response and 0 for an 'incorrect' response.

Knowledge questionnaire

The mean knowledge test item scores for the pre-, immediate post- and follow-up tests are shown in Table II. The mean knowledge score for the immediate post-test was significantly higher than that of the pre-test, indicating that knowledge was acquired. The mean knowledge score for the follow-up test was also signficantly higher than that of the pre-test, indicating that the nutrition knowledge acquired was retained, although no formal reinforcement took place.

Table III indicates the percentage of participants who answered the knowledge test items correctly in the pre-, immediate post- and follow-up tests. The percentage of participants that responded correctly was significantly higher for the immediate post-test than the pre-test for 10 of the 15 knowledge items. There was no significant difference in the percentage of participants that responded correctly to 5 of the knowledge items in the pre- and immediate post-tests. The percentage of participants that responded correctly was significantly higher for the follow-up test compared with the pre-test for 11 of the 15 knowledge items, indicating a retention of knowledge. No significant difference was found in the percentage of participants that responded correctly to 4 of the knowledge items in the pre- and follow-up tests.

Table II. Mean knowledge and attitude scores for the pre-, immediate post- and follow-up post-tests (N = 141)

	Total	Pre-test score		Immediate post-test score		Follow-up test score	
Questionnaire	score	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%
Knowledge	15	9.45 (2.93)	63.0	10.92 (2.77)	72.8	10.99 (3.06)	73.3
Attitude	10	6.98 (1.49)	69.0	7.71 (1.47)	77.1	7.86 (1.51)	78.6

Table III. Percentage of participants that answered the knowledge test items correctly in the pre, immediate post- and follow-up tests and significance of differences between the tests (N = 141)

Test item and description	Pre-test	Immediate post-test	P-value*	Follow-up post-test	P-value†
B1 Regular meals and health	91	99	0.002	97	0.05
B2 Food groups and balanced eating	68	79	0.05	83	0.005
B3 Division of food into groups	71	76	NS	75	NS
B4 Cooking of vegetables to retain nutrients	50	60	0.05	62	0.05
B5 Function of body-building food	38	61	0.002	57	0.002
C1 Number of food groups	74	94	0.002	89	0.002
C2 The importance of breakfast	77	96	0.002	94	0.002
C3 Protective foods	82	82	NS	84	NS
C4 Milk versus condensed milk/creamer use	79	73	NS	75	NS
C5 Fibre-rich foods and constipation prevention	70	77	NS	82	0.01
C6 Importance of dark green/yellow vegetables	35	52	0.005	55	0.002
C7 Health and nutritional value of legumes	48	70	0.002	74	0.005
C8 Sugar as 'empty calorie food'	48	67	0.002	64	0.005
C9 Healthy 'lunch box'	67	77	0.05	78	NS
C10 Energy foods	40	33	NS	30	0.05

*Significance of differences between immediate post-test item score and pre-test item score.
†Significance of differences between follow-up post-test item score and pre-test item score.
NS = not significant.

Attitude questionnaire

The mean attitude test item scores for pre-, immediate post- and follow-up tests are shown in Table II. The mean attitude score for the immediate post-test was significantly higher than that of the pre-test. This indicates that the participants responded more favourably towards the subject of food, nutrition and health on completion of the CAL nutrition module. The mean attitude score for the follow-up test was also significantly higher than that of the pre-test. This indicates further that the positive attitude acquired towards food, nutrition and health was retained after completion of the module. The percentage of participants that responded favourably to the attitude test items in the pre-, immediate post- and follow-up tests is shown in Table IV. The results of the attitude questionnaire for the immediate post- and follow-up tests were comparable. The percentage of participants that responded favourably was significantly higher for the immediate post-and follow-up tests, compared with the pre-test, for 4 of the 10 attitude items.

Behaviour questionnaire

Central to this study was how participants performed on the behaviour questionnaire. The χ^2-test was used to test the difference in the respective frequencies of the responses on the behaviour questionnaire. Although there were improvements for most of the behaviour test items, no significant differences were found between the frequencies of the responses to the behaviour items in the pre-, immediate post- and follow-up tests, except in the case of three behaviour test items (Table V).

DISCUSSION

Client interest in using the CAL nutrition programme and overall acceptance of using the computer was high. Initial apprehension, ascribed to the fact that the participants had no previous experience with computers, quickly passed and users were soon at ease and able to work comfortably by themselves. They also reported positive feelings about using the computer to learn. Self-directed and self-paced learning were cited as positive aspects of using the computer. The non-judgmental nature of communication and privacy in learning were also cited as positive aspects. These findings correspond with those of Carroll *et al.*[7]

The knowledge results of the immediate post- and follow-up tests were comparable (Table II). The subject matter learned was therefore also retained. The knowledge acquired and retained included the division of food into three food groups and the function of body-building foods. Knowledge acquired regarding the health and nutritional value of legumes and that sugar is an empty calorie food were retained to some extent, while the importance of dark green and yellow vegetables in the vegetable group and the method of cooking vegetables to retain nutrients was well retained. Knowledge acquired regarding the daily consumption of food from all the food groups was also retained to some extent. Although not identified in the immediate post-test, the follow-up test also indicated that the participants remembered that brown bread, rice and porridge are energy foods and that cereals containing digestive bran prevent constipation (Table III). This was possibly the result of application of the knowledge (Table V). The participants also learned that three regular meals should be consumed daily for good health and retained the knowledge to some extent. They also learned that breakfast is an important meal of the day and fully retained the knowledge (Table III).

On and after completion of the CAL nutrition module the participants agreed that legumes are as healthy and nutritious as meat and poultry, that there is a correct method when cooking vegetables, that adults also need to consume milk

Table IV. Percentage of participants that answered the attitude test items correctly in the pre, immediate post- and follow-up tests and significance of differences between the tests (*N* = 141)

Test item and description	Pre-test	Immediate post-test	*P*-value*	Follow-up post-test	*P*-value†
A1 Meal skipping and health	76	71	NS	71	0.05
A2 Type of food and health	58	71	0.05	71	0.01
A3 Legumes versus meat and poultry	52	71	0.002	71	0.002
A4 Importance of breakfast	97	99	NS	99	NS
A5 Cooking of vegetables to retain nutrients	65	82	0.002	82	0.002
A6 Sugar as an energy source	13	13	NS	13	NS
A7 Food intake and health	77	83	NS	83	NS
A8 Brown versus white bread	96	99	NS	99	NS
A9 Importance of milk for adults	66	83	0.002	83	0.002
A10 Daily intake of fruit and vegetables	98	99	NS	99	NS

*Significance of differences between immediate post-test item score and pre-test item score.
†Significance of differences between follow-up post-test item score and pre-test item score.
NS = not significant.

Table V. Frequency of responses to the behaviour test items in the pre-, immediate post- and follow-up tests (*N* = 141)

Test item and responses		Pre-test (%)	Immediate post-test	Follow-up post-test	P-value*
C11	1 meal daily	4	0	0	0.005
	1-2 meals daily	38	21	23	
	3 meals daily	59	79	77	
C12	No breakfast	2	1	2	NS
	Daily breakfast	75	79	84	
	Occasional breakfast	23	21	14	
C13	< 1 cup milk daily	39	22	17	0.005
	1-2 cups milk daily	40	43	60	
	> 2 cups milk daily	21	35	23	
C14	No legume intake	4	1	1	0.01
	Occasional intake	48	30	33	
	Weekly intake	49	69	66	
C15	Fresh/powdered milk use	87	87	89	NS
	Condensed milk/creamer use	8	9	10	
	No milk use	5	4	1	
C16	No fruit and vegetable intake	1	0	0	NS
	Daily fruit and vegetable intake	70	78	77	
	Occasional intake	30	22	23	
C17	No fruit and vegetable intake	1	0	0	NS
	> 4 fruit and vegetables daily	36	45	46	
	< 4 fruit and vegetables daily	62	55	54	
C18	Vegetable preparation: lot of water	50	51	46	NS
	Vegetables half-covered with water	37	35	36	
	Bottom of cooking utensil covered	13	14	18	
C19	Use of brown bread	46	58	60	NS
	Use of white bread	15	16	7	
	Use of both	39	26	33	
C20	No sugar in tea/coffee	2	0	2	NS
	1 teaspoon sugar in tea/coffee	20	33	29	
	> 1 teaspoon sugar in tea/coffee	78	67	69	

*Significance difference: χ^2-test for difference of frequencies.
NS = not significant.

daily and that the type of food eaten is important in the diet. The very high percentage pre-test agreement of the participants with two of the attitude items indicates that these items together with their tutorial matter may not be necessary in a CAL nutrition application. It is evident that the participants agree with the fact that breakfast is an important meal (pre-test agreement of 97% and 99% agreement for the post- and follow-up tests) and that they should eat fruit and vegetables daily (pre-test agreement of 98% and 99% agreement for the post- and follow-up tests) (Table IV). Data from the behaviour questionnaire (Table V) indicated that the participants do consume breakfast and fruit and vegetables daily and that the behaviour did not change over the study period. The attitude item regarding the necessity of daily intake of sugar for energy had the lowest entry-level score. Only 13% of the participants thought that sugar need not necessarily be consumed daily to provide energy. No improvement in this score was found on completion of the programme (Table IV). Although the participants had learned and retained the knowledge that sugar is an empty calorie food (Table III), they still believed that sugar must be consumed daily to provide energy. The associated tutorial matter needs more emphasis, as it did not change the participants' belief.

A significant difference in the frequencies of the three questionnaires was indicated for the number of meals, the amount of milk and dairy products consumed per day, and the intake of legumes. On completion of the programme the participants therefore consumed more meals and milk and dairy products per day and incorporated legumes more regularly into their diets. They also retained this behaviour after completion of the programme (Table V). The knowledge gained that regular meals should be consumed daily and that breakfast is an important daily meal (Table III) could have contributed to the regular daily meal consumption. The regular meal consumption could be attributed to the more regular intake of lunch and/or supper, not breakfast, as the frequency

of the responses to the consumption of breakfast did not change over the study period (Table V).

The positive attitude and knowledge gained about the nutritional value of legumes (Tables III and IV) and the realisation that adults also need to consume milk daily (Table IV) could be responsible for the more regular consumption of legumes and the daily consumption of milk and dairy products (Table V).

In conclusion, the study found use of the interactive CAL nutrition module to be a viable method of delivering nutrition education to a low-income, low-literacy audience. Viewing the modules resulted in positive changes in knowledge, attitude and behaviour. Use of the computer and the software material also resulted in the retention of the positive changes in knowledge, attitude and behaviour. It seems that the benefits of using computers in the clinics may outweigh the drawbacks.[7] Besides financial implications, the cited drawbacks include clients feeling that they have been abandoned by the health personnel and a dislike for mechanisation or automation, often felt by older persons. Most clients have affection for the health personnel. Combining the computer and personal interaction would be the more appropriate method.[7] Health personnel must be available to answer specific client questions.[7] Printed information should be used to reinforce the CAL information.[7] The CAL nutrition module was positively received by the health personnel and they readily integrated the use of the computer into the clinic environment. As clinic attendances and health personnel shortages and workloads have increased, fewer clients receive individualised tuition. Health personnel are therefore becoming more dependent on handouts, pamphlets and other methods to deliver nutrition education. Health personnel could be better utilised by targeting their education efforts towards more high-risk cases.[7] The computer can also be used to fill waiting times.[7]

Acceptance of the CAL nutrition programme is also indicated by requests from the clinics for availability of the module in English and Xhosa. The module has since been expanded and translated into English and Xhosa. The additional modules are: General Health (which includes topics such as food hygiene, alcohol consumption and tuberculosis), Feeding the Baby (which includes topics such as breast-feeding, pregnancy, the growth chart, diarrhoea, infant feeding, preparation of baby food and the sick baby) and Nutrition and the Family (which includes the toddler; the schoolchild, with reference to the 'lunch box'; teenagers and the elderly; and the family budget, with reference to the haybox and food gardens).

IMPLICATIONS FOR RESEARCH AND PRACTICE

The importance of proper nutrition to the health and wellbeing of all human beings is undisputed. Nutrition knowledge therefore has to be imparted and nobody is more in need of it than the less privileged members of society. Good nutrition would lower their constant risk of health problems as well as enhance their ability to work and be active.[8] Nutrition educators have demonstrated that enhanced communication efforts can improve the health and wellbeing of populations in developed and developing countries.[9] CAL is a means of nutrition education that can provide a valued service to recipients.[7] Studies indicate that instruction via computer results in higher test scores compared with conventional methods, as well as greater long-term retention.[10] Nutrition educators are therefore encouraged to become familiar with and explore the opportunities and challenges of computer technologies to enhance their efforts in nutrition education.[9]

It must, however, be kept in mind that the use of technology will not guarantee successful nutrition communication and education. The design of the software material and careful targeting of a specific community is critical. CAL nutrition applications will only be successful if they are designed to reach out to people and entice them to improve their food choices. Elements such as storytelling and interactivity are essential to engage the user. It must also be kept in mind that while computers provide a powerful medium, other means of communication may be more appropriate in a given situation.[9]

We appreciate the contribution of the personnel at the clinics and the participants, as well as that of the statistician, Mr J Stupart. Without the approval and assistance provided by the Departments of Health and Education, the study would not have been possible.

References

1. McMurray P, Hoover LW. The educational uses of computers: Hardware, software and strategies. *Journal of Nutrition Education* 1984; **16**(2): 39-43.
2. Byrd-Bredbenner C, Bauer K. The development and evaluation of computer assisted instruction modules for an introductory, college level nutrition course. *Journal of Nutrition Education* 1991; **23:** 275-283.
3. Magnus MH, Roe DA. Computer-assisted instruction on drug-nutrient interactions for long-term caregivers. *Journal of Nutrition Education* 1991; **23**(1): 10-16.
4. Schroeder L, Thiele VF. Renal diet therapy — A computer-assisted instruction model. *Journal of Nutrition Education* 1981; **13**(1): S111-S114.
5. Turner RE, Evers WD. Development and testing of a microcomputer nutrition lesson for preschoolers. *Journal of Nutrition Education* 1987; **19:** 104-108.
6. Lo R, Lo B, Wells E, Chard M, Hathaway J. The development and evaluation of a computer-aided diabetes education program. *Australian Journal of Advanced Nursing* 1996; **13**(4): 19-27.
7. Carroll JM, Stein C, Byron M, Dutram K. Using interactive multimedia to deliver nutrition education to Maine's WIC clients. *Journal of Nutrition Education* 1996; **28:** 19-25.
8. Fuller Knapp ST. Reflections on nutrition education for the rural, low-income community. *Nutrition Today* 1991; Nov/Dec: 32-37.
9. Kolasa KM, Miller MG. New developments in nutrition education using computer technology. *Journal of Nutrition Education* 1996; **28:** 7-14.
10. Beerman KA. Computer-based multimedia: New directions in teaching and learning. *Journal of Nutrition Education* 1996; **28:** 15-18.