Designing Computer Assisted Instruction Programs for Diabetic Patients: How Can We Make Them Really Useful?

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ABSTRACT

Despite the increasing potential of computers for educational use, experience shows that few Computer Assisted Instruction (CAI) programs for patient education have been accepted into routine use by health care providers. A CAI program on hypoglycemia for insulin dependent diabetics, which was developed by the authors and has been widely used in Europe for over 6 years, is described and is used to illustrate some specific difficulties and possible solutions when using computers for patient education. We hope to show that patients suffering from a chronic disease, such as diabetes, require specific skills which are very different in nature from the theoretic knowledge they usually receive from different sources, including health care providers. In order to be really useful, a CAI program for patients must help them to cope with their disease and take into account patients' concerns, fears, and misconceptions as far as possible. Far beyond a detailed knowledge of the domain, a deep experience in patient education is mandatory to understand patients' needs.

INTRODUCTION

The role of patient education in the management of diabetes is now widely accepted [1,2]. However, it is also well recognized that it is a difficult task to organize an integrated health care plan in which the medical team devotes equal emphasis to the biomedical and educational aspects of treatment [3]. Computer Assisted Instruction (CAI) has been proposed for several years in this field to achieve one or more of three basic objectives [4,5,6]: a) to save time, effort (and money), enabling existing staff to train more patients; b) to provide a higher quality of teaching, learning (and assessment); c) and to provide the intellectual challenge necessary to force teachers to re-examine their teaching objectives, methods, and materials.

To date, however, only few CAI programs have been accepted into routine use by health care providers. Why? Today, a common answer is to say that the current limitation of most existing CAI programs lies in their inability to reach the appropriate level of "intelligence" involved in the educational process.

Artificial Intelligence is undoubtedly bringing new hopes to this issue, but still, most projects have done more to reveal problems than to fulfill promises [7]. We have developed a CAI program on hypoglycemia for insulin dependent diabetic patients (IDD) that we have been using for over six years [8,9,10,11]. This program has been translated into six different languages and is now quite widely used in Europe. This paper briefly describes the program itself and discuss some specific aspects of patient education that can help a CAI program to leave the laboratory and be put into use.

CAI PROGRAM ON HYPOGLYCEMIA

a) **Goals.** Experience in the field of patient education constantly shows how difficult it is to systematically teach patients, despite the use of structured education programs [12]. Information is more likely to be given to highly motivated patients or following a crisis. [13] Moreover, the information patients receive tends to concentrate on physiopathology, at the expense of the presentation of clinical situations which the patient is likely to encounter and is capable of understanding. The flow of information tends to be unidirectional [14] : the medical team is seldom aware of a given patient's level of knowledge or attitudes, and hence ill equipped to detect his mistakes and deal with them appropriately and effectively. This lack of feed-back is not conducive to reaching concerted objectives within the team. Even if some feed-back may take place, it is usually not passed on to the other team members, so that the medical team is frequently ill informed about the overall knowledge of a

patient and even more so about the knowledge of a group of patients. Our computer assisted instruction program on hypoglycemia was therefore planned to meet the following objectives :

1° to provide a systematic teaching tool which is sufficiently flexible to take into account the specific needs of each patient and which can also be used by his family,

2° to give the medical team a means for assessing the knowledge and attitudes of patients and their families providing a printout showing the mistakes that patients make in their day to day life with diabetes.

b) Hardware. This CAI program runs on any Apple Macintosh computer. This system was chosen for its user friendliness, excellent screen definition and for its easy access to patients and health care professionals. The program was optimized and it's data were compressed so that a hard disk is not necessary to use the program. The patients' answers are automatically stored on a magnetic disk. Approximately 1000 patients can be filed on a double-sided 3"1/2 floppy disk (800 kilobytes). The keyboard is necessary to introduce patient's identification details. A numeric keypad, a mouse, a graphic tablet, a touch-screen or a conventional keyboard may be used to complete the rest of the program. A printer is required to obtain permanent copies of summaries, interpretation, graphs and statistical analysis.

c) Software. The course was written with a specially designed authoring program which was itself written in "C" language. A full description of this authoring program is beyond the scope of this paper. Details have been described elsewhere [8]. Its basic features are a mouse-based screen editor and an object-oriented authoring-language which allows a controlled flow of the courseware in a non-procedural way.

d) Courseware. The CAI program on hypoglycemia is built up using explanations, pictures, questions and comments covering the following 6 sections :

1. Definitions.
2. Patients personal signs and symptoms.
3. Causes (nutrition, insulin, physical activity, schedule).
4. Prevention.
5. Treatment.
6. Specific situations (driving a car, travelling, passing exams, important meetings, etc.).

The questions included in the program pursue several goals such as: a) assessing the patient's baseline knowledge, b) collecting information about his personal history, treatment, symptoms, and attitudes towards

hypoglycemia, c) evaluating his understanding and assimilation of the explanations given by the program, d) problem solving exercises, etc. For each answer, the patient immediately receives specific explanations and commentaries which can also vary with the answers to previous questions. For example, the program won't give the same advice to a patient on one or two daily injections of intermediate-acting insulin as it would to a patient on multiple daily injections of regular insulin. Also, the program will progress differently according to the patient's answers. Therefore, patients do not all answer the same questions. From a total of 120 questions, about 60 are routinely put to all patients and an average of 20 others are selectively asked according to criteria such as patient's history, basic knowledge, attitudes, etc. For the most important questions, the patients not only have to give an answer but they also have to express the degree of confidence for their answer on a scale of 1 to 3. This is important for three reasons: first, it is necessary to prevent the patients from guessing the answer, particularly when answering multiple choice questions. Secondly, patients can't put their knowledge into practice unless they are reasonably confident about it. Thirdly, it may reveal the patient's strong beliefs in common misconceptions [15]. It is important to be able to detect and report such misconceptions to the medical team.

The average time to complete the program is about 1 hour. It is possible to interrupt at the end of each of the 6 sections, re-entering it where left off or redoing a section if this is desired.

e) Printout. Directly after finishing the program each patient receives a printed summary of the mistakes he made. This printout enables the patient to take home a written document containing all the points which he should remember. The health care team receive a copy of the patient's printout, and systematically rediscusses all the difficulties with the patient. A copy is also included in the patient's file. The printout is divided into 2 sections. The first part (10-30 lines) evaluates and comments the patient's personal risk of experiencing hypoglycemia. It is based on certain answers concerning patient's history (signs and symptoms), his capability of preventing hypoglycemia from occurring, his manner of treating them should they occur (e.g.: patient without carbohydrate on him, without glucagon, family not trained for glucagon use, etc.) and by assessing the patient's knowledge about food (food exchange, quick acting carbohydrate etc.). This part of the printout is a plain text which is dynamically generated by the computer.

The second part of the printout examines questions the patient answered incorrectly. This part is technically much simpler than the first one and makes use of simple

canned text. Each incorrectly answered question is commented by an explanation 1-3 lines in length.

f) Evaluation. The program has been tested for it's acceptability by patients and health care providers [8] and a comparative study has been performed by an independent team [10]. In summary, it has been shown that quite a large part (36%) of patients are initially not keen to use a computer for learning. After using the program, more than 85% were favorable to this technique. The comparative study has shown that the CAI program was much more efficient than conventional group teaching. The average increase of knowledge in the computer group was 62% against 13% in the other group. However, no change was found in attitudes or behavior (e.g.: carrying sugar, eating snacks, etc...) in either groups, suggesting that neither technique was sufficient by itself to change patients' motivations. However, motivated patients from the computer group were more likely to take adequate preventive actions than in the other group.

DISCUSSION

The creation of a CAI program is a long and difficult procedure. The difficulty of producing good-quality material has sometimes left a sense of uncertainty or even disillusion among users as well as designers. The mixed results of numerous CAI programs have often been interpreted by designers as a consequence of purely technical obstacles, offering new hopes in new technologies [7]. In fact, we must admit that little attention has been paid to crucial practical issues which can certainly explain why so many promising systems are disregarded by their end-users. It seems that most systems have been laboratory experiments primarily intended to demonstrate feasibility, rather than being truly designed to be used in a day to day practice.

Designing CAI programs for patients is obviously an interdisciplinary approach where at least three different fields — medicine, education and computer science, are equally involved and need to work together. A number of existing CAI programs have failed just because one of these three fields was not duly taken into consideration. But more importantly, the difference between an interdisciplinary and a multidisciplinary team is frequently misunderstood. An interdisciplinary team is not a mere association of experts with various specialities who have come together for the occasion. In order to be successful, an overlap of skills between all members is essential. For example, the simple inclusion of a specialist of the domain and a specialist in education will not be enough if they do not have a lot of experience in patient education. Moreover, close teamwork with continual contact with the real world is a necessity.

Medical aspects. As far as patient education is concerned, we have observed that a frequent cause of failure in a number of CAI programs was a poor analysis of the medical objectives. If most physicians can easily define long-term objectives (ex.: to improve the metabolic control, to prevent long-term complications, etc...), very few seem able to set small, short-term, realistic goals that the patients can really reach. As a result, patient education is often limited to teaching physiopathology of diabetes, or even biochemistry, rather than cover clinical situations that the patients are going to face in their daily lives. In our experience, the most difficult part of the process was to set up an inventory of relevant factors than can *really* help the patients. If a CAI program is really intended to be used, it also must be useful from the patients' point of view. Far beyond a detailed knowledge of the domain, a deep experience in patient education is still mandatory to understand patients' needs.

Educational aspects. Many health care providers think that "teaching can hardly be learnt" or that "I know, therefore I can teach". Patient education has in some instances been equated with patient information. Much of this suggests that patient education focuses on knowledge. However, if one of the purposes of patient education is to increase the patients' compliance and therapeutic effectiveness, then it is reasonable to assume that the process must involve more than giving information to a passive patient [16]. At least, patients must be able to use their knowledge. This implies that the knowledge must not only be understandable, but also usable. A way to achieve this is to define educational goals in terms of actions that the patients will have to do [17,18,19]. For example, one should avoid defining goals like "the patient must know" or "the patient must understand", but instead try to say "the patient must be able to choose food containing fast absorbed carbohydrate", or "the patient must enumerate 3 precautions to take when travelling or driving a car".

Since Piaget [20], it is commonly recognized that education is an active process involving the learner as a mutual participant. However, this doesn't mean that the students have to "discover" the knowledge all by themselves. In recent years, we have seen an explosion of "hypermedia" technologies, where students are allowed to "browse" an often large amount of data on a computer. This approach can be compared as a group of children left by themselves in a museum. It offers only the opportunity of education. But there is no guarantee that the students will learn anything [21].

A further difficulty resides in finding the balance between complexity and simplicity, even if the software tools allow for different levels of difficulty for each

particular patient. If they are too simple, too meager, the programs would be of limited use. If too complex, the programs would only benefit "élite" patients who are already often advantaged by traditional teaching methods. Most of the CAI program for patients we have seen could be classified in the latter category. Elitism may be acceptable at school level, however it is contradictory to the aims of patient education. A CAI program intended for patients should be accessible to all of them. Therefore such programs should be designed considering patients' individual needs and abilities as far as possible.

Computer aspects. Among the many causes that can prevent a computer program from being used in a daily practice, the lack of user-friendliness is certainly among the top few. All too often, systems have been designed without performing any feasibility study with the end users (in our case, the patients and the medical team).

In our experience, a preliminary study with 50 diabetics has shown us that the use of open-ended questions was definitely unrealistic with patients: it was clearly too difficult for most of them to give an answer by using a keyboard. The mouse also had to be discarded since only two patients among the 50 who were tested knew how to use this device. Our purpose was obviously not to teach patients to use a mouse and we considered that the time needed to learn even the most elementary skills (10 - 15 minutes in the best cases) was still too long in relation to the time needed to complete the program. It was therefore decided to use multiple-choice questions, allowing answers to be given through a numeric keypad. Keypads were considered much more familiar to patients as they look like those found on most telephones. Our preliminary study also included 16 different ways of presenting questions or explanations on the screen and to solicit patients' answer. It became rapidly apparent that most patients were unable to understand the metaphors commonly used on most window-based systems, such as overlaying windows, buttons, check-box, icons or pull-down menus, etc. Even a very simple interface such as a teletype-like display was problematic for a number of patients. Many of them didn't pay attention when a new item appeared on the screen and were indefinitely waiting to see something to happen on the screen. Other patients were mistakenly thinking that the screen had changed and read twice the same information without even being aware of it. After several trials, we placed a cartoon figure in the left border of the screen to "present" the information or the questions (Fig 1). When the patient gives his answer, the figure moves to the bottom of the screen where a second window appears for asking the degree of confidence (Fig 2) or for displaying a comment to the answer (Fig 3). We observed

that no more patients read the wrong part of the screen with this method.
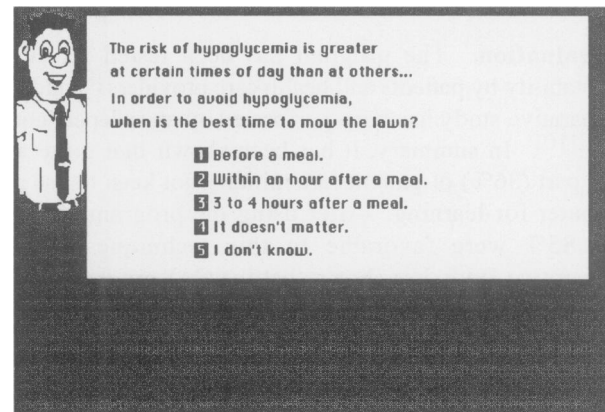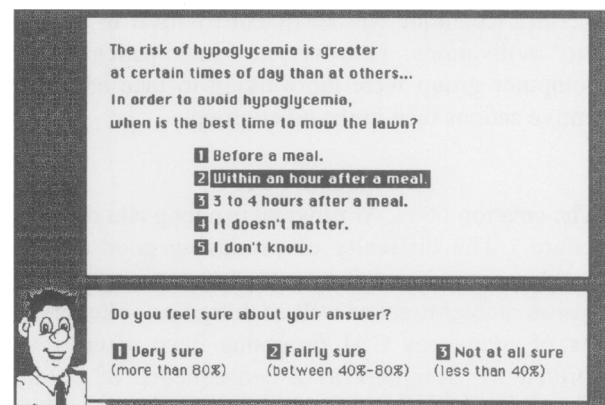

Fig 1: *Question*

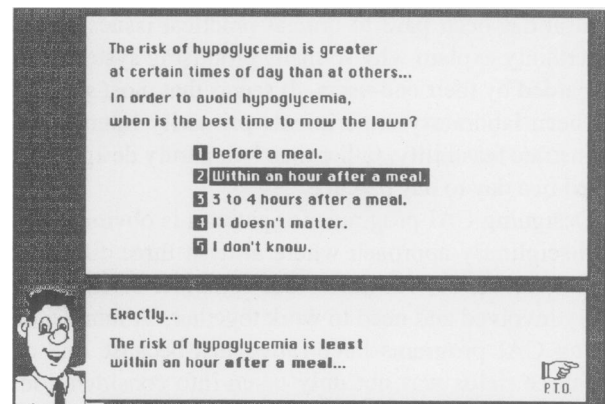**Fig. 2:** *Degree of confidence*

Fig. 3: *Comment*

The experience we have made by using our program for over six years shows that it is not only able to address patients' concerns about diabetes, providing answers to some routine questions, but also to stimulate additional questions from the patients. On the other hand, the information collected by the printout can expose gaps in the patients' knowledge and attitudes which till then had gone unnoticed. These two features are very appreciated by the medical team and the patients and probably explain

much of the program's success. Also, it becomes apparent that information collected through anamnestic questions which are usually asked by the physician are rarely transmitted to the other members of the medical team. Similarly, observations made by the dietician concerning patients' errors rarely reach the physicians or the nurses. The printout serves as a concrete mediator between the different team members, the patient and his family and appears to be an excellent means for improving the communication flow concerning concerted objectives. From the patients' point of view, the CAI program is considered as an extension of the health professional, not as a replacement for contact with the professional. This keeps us convinced that CAI programs are valuable only to the extent that they facilitate communication between patient and health professional and not insofar as they can replace interaction.

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