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DEVELOPMENT AND EVALUATION OF A COMPUTER-BASED EDUCATIONAL PROGRAM FOR ADULTS WITH CONGENITALLY MALFORMED HEARTS

Short title: Evaluation of an educational program

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Abstract

Background: There is a lack of educational material for adults with congenitally malformed hearts. Computer-based education has shown to have significant effects on knowledge and management of chronic diseases.

Aim: The aim of this study was to develop and evaluate a computer-based educational program for adults with congenitally malformed hearts.

Methods: The program was developed by a multidisciplinary team. Data were collected by questionnaires, observations and structured interviews.

Results: The final product was a computer-based educational program consisting of ten separate modules, one for each particular malformation. The program was experienced as stimulating and easy to use. The appearance and quantity of the text was graded as good and the content as relevant and very useful.

Conclusion: This is the first computer-based program developed for adults with congenitally malformed hearts. The evaluation found the program to have great potential as an important tool for improving care. Further studies are needed to test the outcomes of the program on knowledge, perceived control over the heart condition, anxiety/depression and health-related quality of life.

Practice Implications: The program may be used as a complement to verbal information and every adult with a congenitally malformed hearts can receive individualised information from a personal CD.

Keywords: patient education, patient information, hospital outpatient clinic, congenital heart disease.

1. Introduction

The number of adults with congenitally malformed hearts is increasing due to improvements in medical and surgical care [1]. This group has been found to have a poor level of knowledge about various aspects of their congenital heart malformation and there is a lack of educational materials [2-6]. To date, the education has often been given as verbal information, complemented with pictures of the heart and copies from medical charts, provided by the responsible cardiologist [7]. Another source of information is the Internet. Web-based information is easily accessible to everyone. However, the quality of the content varies and some information might be too unspecific or difficult to understand [8]. Computer-based education tailored for the individual is a multimedia learning tool that has shown significantly increasing effects on knowledge and/or management of the disease in people with chronic illness [9-13].

1.1. Theories of education and multimedia learning

Behaviourism and constructivism are two major educational theories that medical educational systems are often based upon [14-15]. Behaviourism is a technology-centred approach; learning occurs by information and repetition, rote-learning. The learning outcome is the ability to repeat information, without the ability to transfer it to other situations (surface approach). Constructivism is a learner-centred approach; learning occurs by building on prior knowledge and relevance (meaningful learning). The learning outcome is the ability to repeat and transfer the information to new situations, understanding is reached and deeper knowledge occurs (deep approach) [15].

When developing a computer-based educational program the cognitive theory of multimedia learning should be considered [14, 16-17]. According to this theory humans have dual channels for learning i.e. visual/pictorial and auditory/verbal processing. Learning is a constructive activity and each channel has limited capacity for processing knowledge by itself [18]. Thus, there is an advantage using multimedia learning i.e. selecting relevant words/images, organising the selected words/images into verbal/pictorial representation and integrating them into prior knowledge. When using the theory of multimedia learning cognitive load is also taken into consideration [19].

To increase the meaningfulness and usability of the educational program it is extremely important to include not only the experts but also the users in the development [20-21]. It is also important to describe the development to validate the program.

The aim of this study was to develop and evaluate a computer-based educational program for adults with malformed hearts.

2. Methods

The study consisted of three parts: 1; development of ten modules for the different congenital heart defects, 2; initial evaluation of the beta versions of the ten modules and 3; final evaluation of the revised modules (Table I).

The study was approved by the Regional Ethical Review Board in Linköping, and the principles outlined in the Declaration of Helsinki were followed throughout the study[22].

The program was developed by a multidisciplinary team and adobe Flash player technique was used. The program included 2-D graphics, animations, narratives and text on screen.

Assessment was made by standard methods in computer system development, such as questionnaires, observations and structured interviews [23-25]. Usability, comprehensibility and appearance were evaluated. Usability is defined as "the extent to which a product can be

used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (ISO 9241-11:1998). Comprehensibility is defined as “the extent to which a graphical symbol is likely to be interpreted with the intended meaning” (ISO 17724:2003), and appearance as “all the visible attributes of a substance or object” (ISO 5492:2008) [26].

2.1. Part 1 Development

As shown in Table I, a prototype (ventricular septal defect) was produced first. Before the content of the prototype was set, an interview study was performed in 16 adults with congenitally malformed hearts in order to explore their educational needs [7]. The program format was decided to be a CD rather than being web-based. At the time all users did not have access to the Internet and the size of the animations made the program difficult to download over the Internet. The main content and areas were selected by the researchers based on the literature [27-34] and clinical experience. The content of the program was meant to fit in with the users’ knowledge and needs by answering frequently asked questions. It was developed as a complement to verbal information, using terminology that is easy to understand in order to allow formal users to gain a more complete understanding of their congenital heart defect and its possible effects on daily life. The computer-based education was not aimed to be a complete textbook. To control the standard and verify the appropriate language level of the program, speaker narratives were checked by a licensed Swedish translator/editor. The reading level of the modules was not formally assessed. Each main area ended with a self-conducted test (Picture 1).

The researchers and three formal users tested the prototype individually and answered semi-structured questions during/after using the program. Based on this experience, all ten modules (ventricular septal defect , aortic valve stenosis , atrial septal defect, coarctation of the aortae,

complete transposition of the great arteries, congenitally corrected transposition of the great arteries, Ebstein anomaly, Eisenmenger syndrome, single ventricle, tetralogy of Fallot) of the computer-based educational program were developed. The content and structure of each module is shown in Table II

Please insert Table I and II here.

2.2. Part 2 Initial evaluation

The beta version of the ten modules were then evaluated, see Table I.

The initial evaluation was conducted by a multidisciplinary group of healthcare professionals and formal users. The multidisciplinary group, consisting of three physicians and four nurses, was selected from units specialised in congenital heart disease in Sweden and Norway. All in this group were experienced computer users. Nineteen formal users selected from two hospitals in Sweden, twelve men and seven women, 23-49 years old (mean 35 years) participated. All ten modules were evaluated by two formal users, except for the module on ventricular septal defect, which was evaluated by one user. Five individuals were inexperienced computer users whereas the others were experienced or highly experienced computer users.

In the multidisciplinary group a questionnaire was used for data collection. Observations and structured interviews were used in the group of formal users.

The questionnaire, which was also used in the structured interviews included questions related to usability, comprehensibility and appearance of the content (Table III). It contained multiple choice questions graded on a scale from 1 to 4, where 3 was considered acceptable. It also contained open questions which were analysed and categorised. Data collection in the multidisciplinary group was done individually at home and in an outpatient clinic for the

formal users The participants answered the questionnaire during/after the session. The observation, interview and program session lasted 90-120 minutes.

Please insert Table III here.

2.3. Part 3 Final evaluation

The final evaluation of the revised modules was performed by 49 consecutively selected formal users with the same congenitally malformed hearts as in the ten modules, 25 women and 24 men, aged 19-74 (mean 34 years). The program was distributed in the outpatient clinic and the formal users worked with it individually. Data regarding usability were collected through four questions in the questionnaire that were answered after using the program. After the evaluation the formal users received a CD to take home. The module Single ventricle was not evaluated due to the consecutive selection of formal users.

3. Results

3.1. Part 1 Development

The content and structure of the prototype were satisfactory and the ten modules in the program were now developed including 55-60 minutes of information each. The modules contained the same eight main areas and subheadings covering different aspects of the subject (Table II).

Cognitive functions regarding content related to usability, comprehensibility and appearance were important during the development of all ten modules. The animations, narratives and text on screen were developed to be as comprehensible as possible (Picture 2). Attempts were made to construct the program to suit different learning styles. This was done either by looking at animations and listening to the speaker or by merely reading the text on screen by means of a pop-up window. Pages without animations contained headlines on the screen and

were synchronised with the speaker narratives (Picture 3) except for the subheading "Symptoms" in all modules that contained animation, speaker and headlines (Picture 4).

Please insert Table IV here.

Please insert Picture 1- 4 here

3.2. Part 2 Initial evaluation

The results of the initial evaluation are presented in Table IV.

3.2.1. Usability

Thirty evaluations in the multidisciplinary group and 16 in the group of formal users graded the relevance of the program as very good. Most of the evaluations in both groups graded the usability of the program as very good. Thirty-six multidisciplinary group evaluations and 13 formal user evaluations graded the program as very stimulating. On the whole all (multidisciplinary group and formal users) graded the totality of the computer-based education as very good, or good. All evaluations in both groups showed that the program was easy to use and orientate in. In the multidisciplinary group there were comments regarding the lack of information about psychosocial and existential questions, arrhythmia and diagnostics. Information about risks of arrhythmia can now be found under the subheading Symptoms. The objective of the program was not to provide information about psychosocial existential questions and diagnostic methods and is thus not given.

In the multidisciplinary group there were comments that the program could be useful in the transition from paediatric to adult healthcare. The formal users commented that they wanted the program to be available at home so that they could watch it alone or with relatives. Formal users commented on ways the program could be made more accessible for people with a

disability such as blindness or impaired hearing. Others commented that a web-link should be connected directly to the Internet, which is now the case.

For the module Eisenmenger syndrome the formal users commented that the content was too comprehensive to look at by themselves and wanted health practitioners present when watching the program for the first time.

3.2.2. Comprehensibility – Appearance

The grading of quantity of text and the appearance, graphical interface of the program varied in both groups. Some in the multidisciplinary group thought the combination of text on screen and a speaker was not satisfactory. One participant in the multidisciplinary group thought the program did not take the opportunity to demonstrate properly the heart disease or associated symptoms. The group of formal users also had comments regarding the content in the modules Transposition of the great arteries and Single ventricle. The content was perceived too heavy do deal with which was confirmed by observations. These two modules were further developed to include animations, narratives and text on screen not only in the subheading" Symptoms", but also in subheadings such as "What does my congenital cardiac malformation look like?" and/or "Surgical treatment". The module Single ventricle was also changed to contain six different pages under the subheading "What does my congenital cardiac malformation look like?" compared to the standard one page in all the other modules. This was done due to that there are so many different types of single ventricles and now the users could choose the page with their specific type instead of looking at all six pages.

One formal user commented on a picture of a pregnant women and the content under the subheading Pregnancy in the module Eisenmenger syndrome. Since pregnancy is prohibited when having this syndrome this picture and the content was removed. Both groups found the content of the subheading Heredity unclear. The program was then modified with support from a geneticist.

The majority of the multidisciplinary group was positive to the self-test (Picture 1), but some questioned its purpose. The group of formal users was more positive and graded the self-test as very good or good. They thought it made them reflect on the content.

In the multidisciplinary group some had comments about the length of the educational program and thought it should be shortened.

There were also comments regarding the structure of the main areas and subheadings. All were taken into consideration and some modifications were made. The observations also resulted in some further development of buttons and of the self-test.

3.3. Part 3 Final evaluation

The results are presented in table IV. Forty-three formal users graded the usability of the computer-based education as very good or excellent for themselves. There were comments expressing relief to find answers to questions that, for various reasons, could not previously be asked. Thirty-seven formal users perceived the content of the program to be excellent or of most relevance for relatives. Forty-seven formal users stated that they would use the program at home. Nineteen formal users thought they would use it many times, 11 would use it two-three times, 13 did not know and 5 thought they would use it once (48 in total, one drop out).

4. Discussion

To our knowledge this is the first initiative to develop a computer-based educational program for adults with congenitally malformed hearts. The reason for developing the program was the lack of educational materials for this group. The strength of the program is that it is based on clinical experience, research literature and developed in close collaboration with formal users**.** The users' needs were the main focus, as this has previously been shown to be the determining factor for the usability of the program [23, 35-36]. Users' experiences are

important, but other experts, in this case physicians and nurses, are needed to evaluate the content if the users do not have experience of the context [36].

According to previous studies of learning, one of the most important aspects to take into consider in order to reach understanding and knowledge, is to have relevant content and illustrations [37, 19]. The content of the current program was verified by the experts and the formal users participating in the study, but also by the literature [38-39].

The objective of our computer-based educational program is to visualise the relationships between the congenital heart defects and the normal heart, what has happened since childhood or can happen in the future as described in the education theory of constructivism. This theory supports deeper knowledge [14, 37]. One area brought up as being important in the expert group was the psychosocial area. From our perspective this was not appropriate include due to the aim of the program. This area should be brought up verbally and discussed individually which has also been confirmed in a previously published study [7].

The users of our program are people at all academic levels and ages using different learning styles [40]. Today we know that text combined with pictures supports the reader's capacity to recall health educational information in brochures [41-42]. However, computer-based education has another advantage; by using both channels into the working memory (by animations, (eye) and sounds (ears)) learning increases significantly [43-45, 18-19]. Another important issue is that the user can integrate existing knowledge more easily by means of relevant content that is organised in a useful way [18]. We have tried to satisfy these needs by developing main areas with subheadings, independent of each other where the users can select freely. Previous studies on health information have demonstrated the importance of knowing how to navigate the content, but also of the level of language. Complicated language and irrelevant content result in lost attention, thus the cognitive load will be too heavy [19].

These can also be identified as too many "extraneous details", which decrease the learning process [46]. Our program was developed with subheadings in the form of questions to simplify the user's choice and to minimise the content to make it relevant to the question (Table II). The language was written in first and second person which has been shown to be the best way to engage in a social-like setting [47]. To engage the users, a self-test was developed after every main area (Table II). These self-tests consisted of easy questions focusing on creating direct feedback to the users thus creating repetitions of the content to support the process of learning (Picture 1).

4.1. Strengths and weaknesses of the study

No formal user with the heart malformation single ventricle evaluated the revised Single ventricle module. This can influence the results of the final evaluation of this module, but not the results of the entire program. Previous studies in multimedia learning have suggested that the combination of animations, a speaker and headlines can be a limitation [19]. However, the user can always turn off the sound and/or the animations and read the text. Due to different learning styles having all three options must be considered as a strength. The large amount of evaluations from both the multidisciplinary group and the formal users have given a good validity of the content. With five evaluations per module, 80 % of all potential usability problems could be found [48].

4.2. Conclusions and clinical implications

To our knowledge this is the first computer-based educational program for adults with congenitally malformed hearts. The users found it to be relevant, stimulating and easy to use and the self-test made the users reflect on the content. Whether this program will improve knowledge and patient-centred outcomes in adults with congenitally malformed hearts is a matter for future studies. If so, the program has the potential to be a very useful complement

to verbally given information, not only to adults but also to adolescents with congenitally malformed hearts. This is especially important as strategies to prepare the adolescents for adulthood in order to prevent the loss of follow-up are lacking [49-51].

Declaration of interest

The authors declare that they have no conflicts of interest. All rights to the computer-based educational program belong to Linköping University and Linköping University Hospital, Sweden. The development and evaluation of the program were undertaken independently of the funding sources and there are no conflicting interests.

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Table I. Description of the flow in the study

Study phase	Participants	Instruments	Outcomes
Part 1: Development	Part of research group [1] Multimedia Developer Adults with congenitally malformed hearts such as ventricular septal defect	Teamwork [I] Semi-structured Question [I,II]	Prototype – ventricular septal defect 10 modules in the Computer-Based Educational Program Aortic valve stenosis Atrial septal defect Coarctation of the aortae Complete transposition of the great arteries Congenitally corrected transposition of the great arteries Ebstein anomaly Eisenmenger syndrome Single ventricle Tetralogy of Fallot Ventricular septal defect
Part 2: Initial Evaluation	Multidisciplinary Group [2] Formal users [3]	Formal Guide [III] Observation [IV] Structured Interview [IV]	Content related to user-friendliness/usability, comprehensibility/appearance
Part 3: Final Evaluation	Formal users [3]	Four Questions	Usability

[1] = 2 physicians, 2 nurses.

[2] = 3 physicians, 4 nurses.

[3] =Adults with congenitally malformed hearts.

[I] Part of research group and Multimedia Developer.

[II] Adults with Congenitally Malformed Hearts such as ventricular septal defect.

[III] Multidisciplinary Group.

[IV] Formal users.

Table II: Eight main areas and their subheadings in each of the 10 modules in the Computer-Based Educational Program

Main areas/Subheadings	Main areas/Subheadings
MY CONGENITAL CARDIAC MALFORMATION	ENDOCARDITIS PROPHYLACTICS
- The normal heart - appearance - The normal heart - function - What does my congenital cardiac malformation look like? - How many people have the same congenital cardiac malformation? - Does my congenital cardiac malformation give symptoms? Test your knowledge	- What is endocarditis? - I – risk for endocarditis? - When – risk for endocarditis? - How to avoid endocarditis? - What are the symptoms of endocarditis? Test your knowledge
CAUSE AND HEREDITY	MEDICAL AND SURGICAL TREATMENT
- Why do I have congenital cardiac malformation? - Is my congenital cardiac malformation hereditary? - Where can I meet other people with congenitally malformed hearts? Test your knowledge	- Medical treatment – my congenital cardiac malformation? - Can I stop the medication? - Surgical treatment – my congenital cardiac malformation? - Other treatments for my congenital cardiac malformation? Test your knowledge
CONTRACEPTIVES AND PREGNANCY	EMPLOYMENT AND SPARE TIME
- What to think about with regard to contraceptives - Issues when planning a pregnancy - Pregnancy Test your knowledge	- Can I do all types of work? - Sport/spare time activities - Risk for my heart when flying? - To think about – when travelling? Test your knowledge
MEDICAL CONSULTATION AND SUPERVISION	SEXUAL ASPECTS AND HEALTH CARE
- Why regular check-ups? - Why not operate on the congenital cardiac malformation now? - Postoperative check-ups? - When should I contact the doctor? Test your knowledge	- Sex life/life together - effects of my congenital cardiac malformation? - My congenital cardiac malformation –self-care issues? - Alcohol, drugs, smoking and moist snuff Test your knowledge

Adults with congenital cardiac malformation, congenitally malformed hearts = Formal users

Table III. Content of the questionnaire

Questions
Grade your previous experience of computers
Do you have previous experience of computer-based education?
Grade every main area/subheading.[1]
Is the computer-based education easy to use?
Is the computer-based education easy to orientate?
Grade the user-friendliness of the computer-based education
Other comments about the user-friendliness of the computer-based education.
If you think there is technology deficiency, state it here.
Grade the relevance of the content in the computer-based education.
Has any area/subheading been given too much space? If so, state it here.
Has any area/subheading been given too little space or is the content unclear? If so, state it here.
Have you perceived the computer-based education as stimulating?
How do you grade the amount of text in the computer-based education?
How do you grade the graphic content in the computer-based education?
How do you grade the questions after every main heading[1] in the computer-based education?
Grade the entire computer-based education.
Other comments.

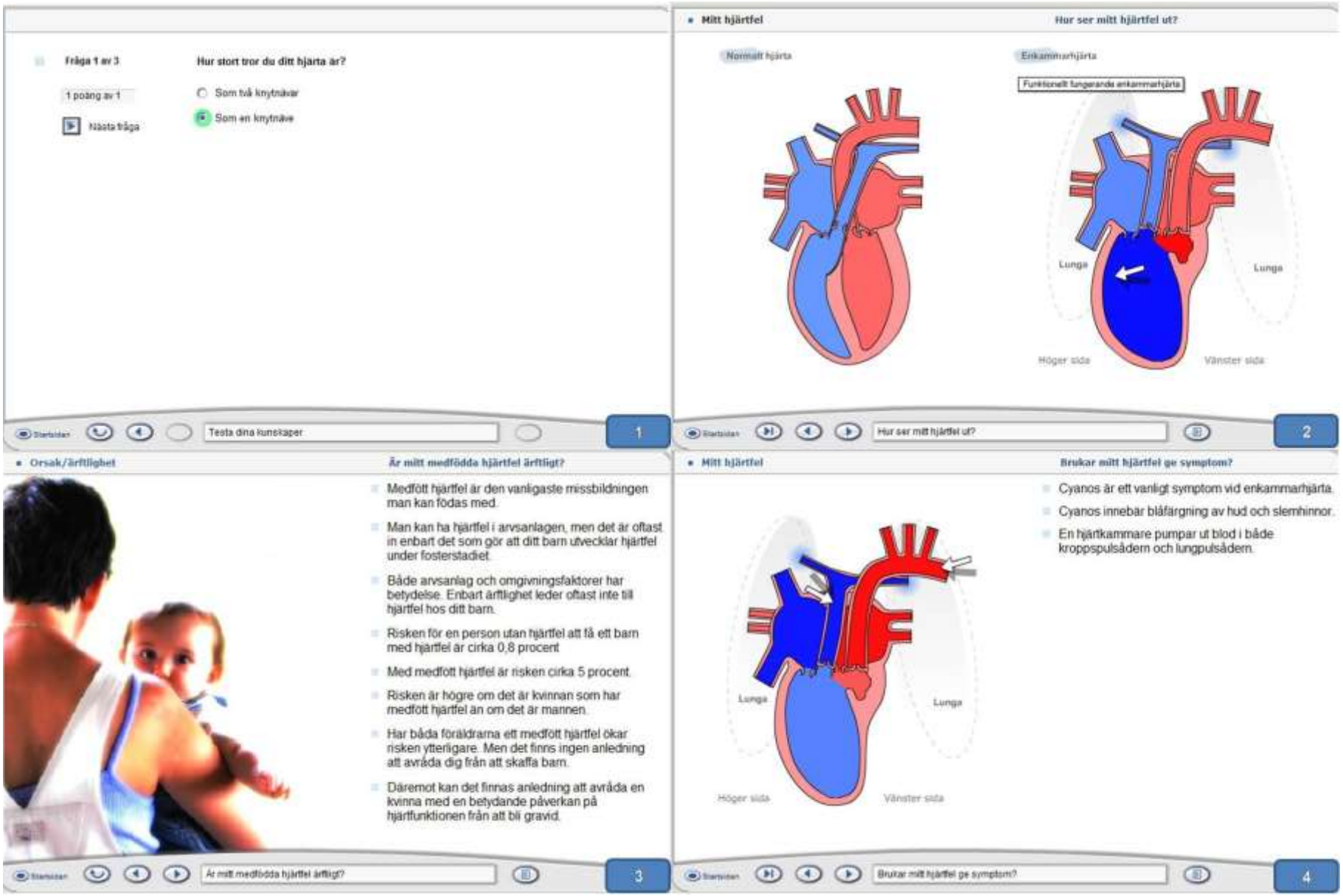
[1]. The different main areas/subheadings are presented in table IV.

Table IV: Part 2 and 3: Initial and final evaluation of the computer-based educational program

Initial evaluation	Multidisciplinary group*				Formal users**			
Usability	Very bad	Bad	Good	Very good	Very bad	Bad	Good	Very good
Relevant	-	-	15	30	-	-	3	16
User-friendly	-	-	4	41	-	-	5	14
Stimulating	-	-	9	36	-	-	6	13
Overall impression of the computer-based educational program	-	-	8	37	-	-	3	16
	Yes		No		Yes		No	
Easy to use	45		0		19		0	
Easy to orientate	45		0		19		0	
Comprehensibility - Appearance	Very bad	Bad	Good	Very good	Very bad	Bad	Good	Very good
Amount of text	-	1	14	30	-	1	8	10
Appearance, graphical interface	-	4	16	25	-	-	9	10
Self-test	-	3	13	29	-	-	8	11

Final evaluation	Formal users***					
Usability	Very bad	Bad	Not so good	Good	Very good	Excellent
For themselves	-	-	1	5	29	14
For relatives****	-	-	1	10	25	12
			Yes		No	
Will use the program at home			47		2	

Multidisciplinary group = 3 physicians, 4 nurses.
Formal users = adults with congenitally malformed hearts.
* 7 participants in the multidisciplinary group = 45 evaluations.
** 19 formal users = 19 evaluations.
*** 49 formal users = 49 evaluations.
**** 1 missing



Pictures 1,2,3,4 from the Computer-based Educational Program. Picture 1: Self-conducted test. Picture 2: Animations, arrows and fingerposts of the flow in the congenitally malformed heart are presented on the screen beside a picture of the normal heart. Picture 3: Pages without animations were developed with headlines on