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DEVELOPMENT OF AND USABILITY FINDINGS FOR A WEB-BASED OSTEOARTHRITIS GUIDE

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ABSTRACT

Osteoarthritis (OA) of the knee and hip causes significant loss of quality of life due to pain, reduced mobility and limited ability to perform usual daily activities. OA is a chronic, debilitating condition that affects up to 18 percent of those aged 65 years and over. The traditional approach to treating this condition has been to involve a number of different healthcare providers, such as specialist doctors, general practitioners, nurses, physiotherapists, dieticians, etc. In addition to healthcare provider care, a patient education and OA self-management system (in the form of a web guide) could possibly also assist sufferers to manage their condition.

This paper describes the OA web guide we have developed. It covers the functionality of the system using the various user interfaces of the guide. A usability experiment was performed with OA experts and end-users to determine the effectiveness of the system and to learn how to improve such a system. The paper also describes the usability experiment and conveys our findings from the experiment.

Keywords: *Osteoarthritis, Web guide, usability experiment, heuristic evaluation, patient education*

1. INTRODUCTION

Osteoarthritis (OA) of the knee and hip causes significant loss of quality of life due to pain, reduced mobility and limited ability to perform usual daily activities. Activities include those such as walking, going up and down stairs, or getting in and out of a car or chair. OA is a chronic, debilitating condition that affects approximately 10% men and 18% women over the age of 65 years [1]. It is estimated that OA will become the fourth leading cause of disability worldwide by the year 2020 if current trends continue [2].

The aims of therapy are to reduce symptoms and prevent disability. There are many effective interventions that can support these aims. However, management of all the issues faced by people with OA often requires effective partnership between patients and a number of different healthcare providers (HCPs). The care of a patient with OA may include contact with a

number of HCPs, including specialist doctors, general practitioners, nurses, physiotherapists, dieticians, podiatrists, etc. There may also be complex decision-making required about safe medication management for older patients who

Our work involves the development of such a system—as a Web system—for assisting the patient with OA of the hip or knee. This Web guide educates the patient regarding various issues about OA, such as those mentioned in the previous
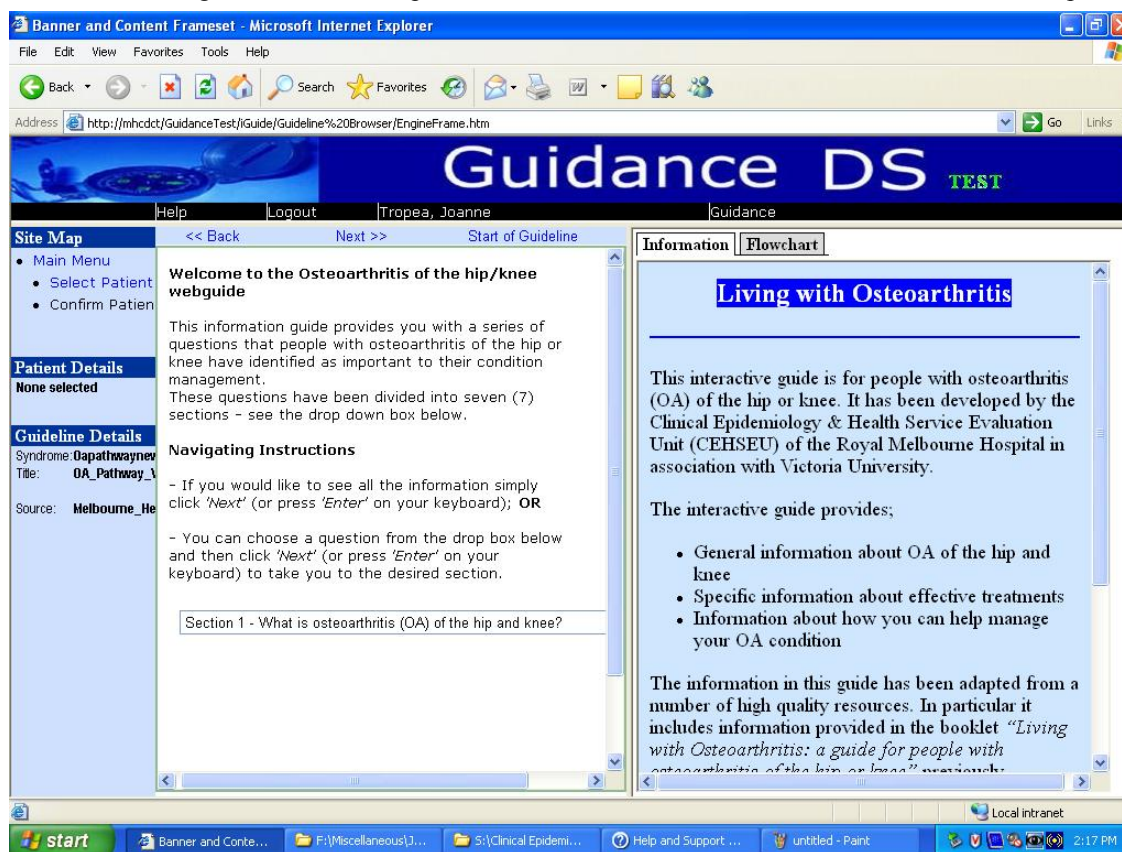

Figure 1: Homepage of OA guide

have conditions such as hypertension, heart, lung or kidney disease.

To assist a patient in providing them the best possible care, in addition to the above partnership between HCPs, it can be very useful to provide patients with a patient education system. Many patient education systems exist for different medical conditions, e.g., diabetes [3], cancer [4] and asthma [5]. Rather than expecting the patient to simply attend consultations with HCPs whenever they can be booked, it is helpful to the patient to educate them about their condition to the extent that patients can "help themselves". For instance, knowing what sort of exercise may or may not help their condition, and information on medications to reduce pain. The aim of such a system is to guide the patient in managing their condition.

paragraph. Our work also involved usability experimentation with this guide to determine its effectiveness and improvements that can be made to it. Feedback from the usability experiment's heuristic evaluation test script was applied to the initial version of the guide and the amended guide is shown throughout section 3.

The Web guide was derived from a publication provided to patients who attend the Royal Melbourne Hospital OA hip and knee service. The Royal Melbourne Hospital is a tertiary teaching hospital in Melbourne, Australia. This publication, "Living with Osteoarthritis: a guide for people with osteoarthritis of the hip or knee" [6], aims to help people to understand more about their condition (OA hip and knee) so that they can share in the decision-making about their health and better manage their OA. The sections in the Web

guide are based on the sections found in the hardcopy publication.

The Web guide was constructed using iGuide® [7]. iGuide® is a component of the GUIDANCE DS® [7] system (a collection of tools for development and presentation of clinical decision support in hospitals) and is "a highly flexible algorithm representation system, able to represent almost any kind of guideline, protocol or flowchart," [7, p. 4]. Using iGuide®, "it is easy for

the evaluation, with three to five evaluators[1]. This has provided us with useful feedback to which we were able to respond by carrying out changes to the guide.

This paper is organised as follows. Section 2 provides a review of relevant literature about work on technology applied to OA. Section 3 covers the functionality of the OA Web guide, including various user interfaces of the guide. The methods involved in the usability experiment are described
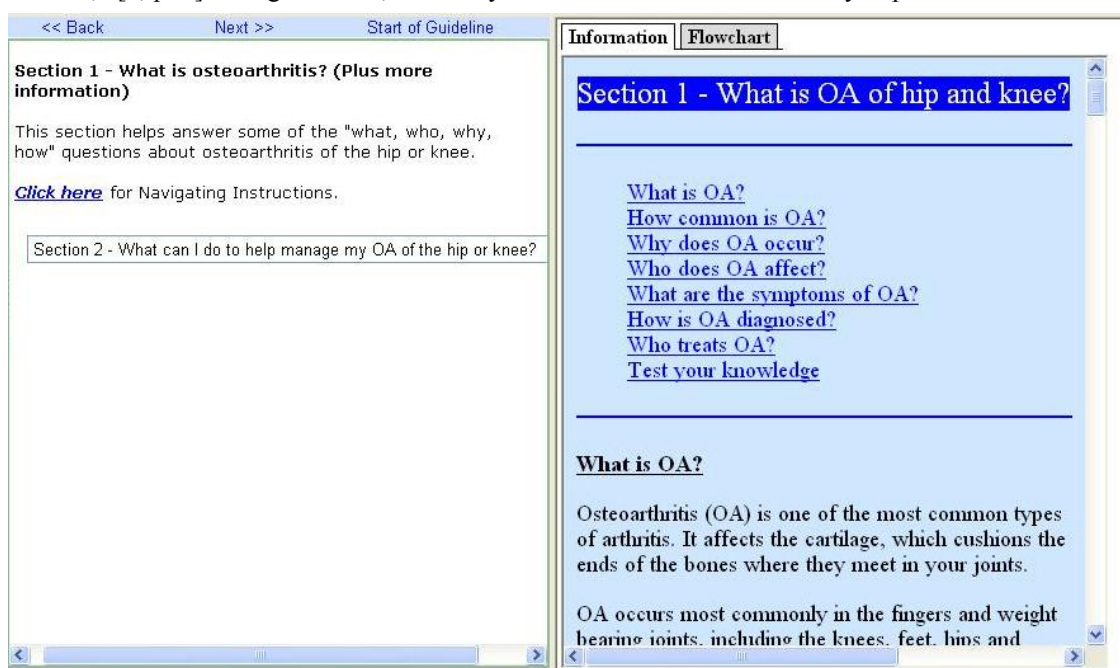

Figure 2: Overall view of section 1 of the guide

the content experts to create new guidelines, and edit or adapt existing ones without having to alter the GUIDANCE DS® application itself in any way" [7, p. 4].

After developing the initial version of the guide, a usability experiment was done to determine how effective the guide was and how it could further be improved. The experiment involved the use of a heuristic evaluation script where clinicians and people with OA (consumer) were the evaluators. The clinicians we targeted were rheumatologists. Therefore, this paper contains the feedback of two clinicians and one consumer with regard to the guide's initial version. The paper also illustrates user interfaces of the second (and final) version of the guide after the feedback of clinicians was applied to the first version of the guide.

Heuristic evaluation is known to be most effective, particularly in terms of costs of running

in section 4. The next section, section 5, covers the results of the usability experiment. Section 6 concludes the paper.

2. LITERATURE REVIEW

The closest work to ours consists of the following five projects.

Rippey et al [8] describe a computer system they developed for educating older OA patients. Their system is quite antiquated as it was developed almost 22 years ago on an Apple IIc computer, and is not a Web (not even hypertext-based) system. These researchers provided eight lessons to patients regarding areas of treatment and self-management. The system was very successful in improvement of patients' knowledge, and as well, using heat, exercise and taking rest. Their system

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[1] http://www.useit.com/papers/heuristic/heuristic_evaluation.html

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was aimed at older patients, whereas our system is useable by patients of any age. As a result, our findings are not particular to older patients.

A similar education system was developed by Wetstone et al for patients with rheumatoid arthritis [9]. This system is just as old as the Rippey's - these early researchers demonstrated insight and forward thinking to develop these systems many years ago. The latter system yielded the following benefits relating to the patients:

❑ improvement in knowledge of the condition

❑ sizes of buttons and text, and layout assisted accessibility to patients with a decrease in their motor skills

all of which helped 'So You have Arthritis' to be "favoured" [10, p. 1419] by patients.

The aim of Bischoff-Ferrari et al [11] was to validate the Western Ontario and McMaster Universities (WOMAC) 3.1 osteoarthritis index in a touch screen version. The WOMAC 3.1 osteoarthritis index is "the best validated and most widely used outcome measure in subjects with hip or knee osteoarthritis" [Bischoff-Ferrari et al, p.
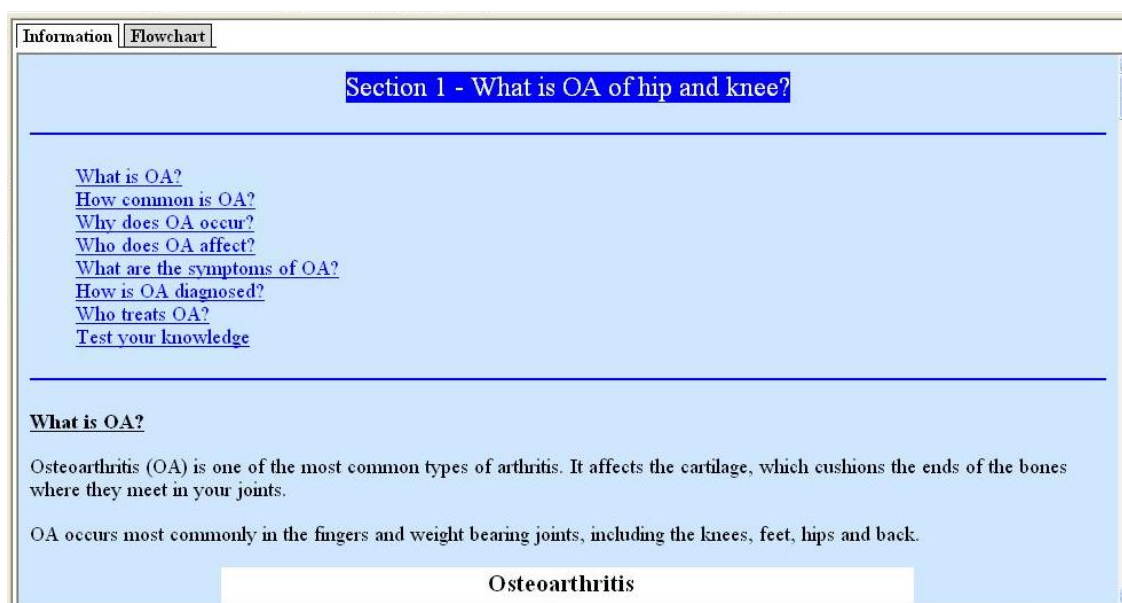

Figure 3: Information pane for section 1

❑ a better outlook regarding life
❑ hope in a positive prognosis
❑ more use of approaches like joint protection and resting
❑ lesser belief in fate or luck influencing patients
❑ enjoyment in using the system

Webb et al [10] evaluated two touch-screen multimedia patient information systems for rheumatology at Barnsley District General Hospital NHS Trust, UK. Twenty patients gave feedback via a questionnaire in interviews on the 'Out Patient Advice Link' and 'So You have Arthritis' systems. The findings included:

❑ the acceptability of touch-screen technology to older patients
❑ patient approval of speech and diagrams

80]. The system "applies each question as a cartoon in writing and in speech (QUALITOUCH method)" [11, p. 80]. The main results were that:

❑ 74% of subjects either found the paper format of WOMAC 3.1 easier to use or were undecided about whether the paper or computer format was easier to use
❑ 53% of subjects did prefer to use the computer format.

Finally, another work that can be mentioned, but uses computing in a relatively minor way, is that of Fries et al. The researchers describe a form of education of patients in OA involving "computer processed recommendation letters and reports individualized to age, diagnosis, education level, disability, pain, medication, and other patient-specific variables" [12, p. 1378]. The researchers

investigate education of patients using mail where computing is only used to process the letters and reports. This particular approach was found successful in that patients' consultations by doctors were reduced by 16% and missing of work or domestic confinement was reduced by 52%.

To make the coverage of literature complete in scope, the following work is also described. These technologies and systems are not systems used by patients as end-users, and therefore do not relate to patient education. They are technologies and systems used in detection or analysis of OA conditions, and therefore are used by health care practitioners.

Banerjee, Schaefer and Vlachos [13] use Cellular Neural Network techniques "incorporating image enhancement, region segmentation and line detection for detecting the manifestations of osteoarthritis" [12, p. 1369]. Detection of OA occurs from X-rays of hands using algorithms that combine analog and logic operations. These algorithms were found to be successful in detection from their experiments.

Shamir et al [14] have developed a technique to automatically detect radiographic OA within X-rays of the knee. The researchers have applied the Kellgren-Lawrence (KL) classification grades, which is a classification that reflects varying severity of OA. The work involved experimentation with 350 X-ray images classified by KL grades. The results of the experiment were that minimal OA was differentiated from normal cases by 80.4% and moderate OA was differentiated from normal cases by 91.5% revealing that their method was highly effective.

A new method for computer-based analysis of the trabecular bone structure is covered in [15]. The method uses both a Fourier transform and a
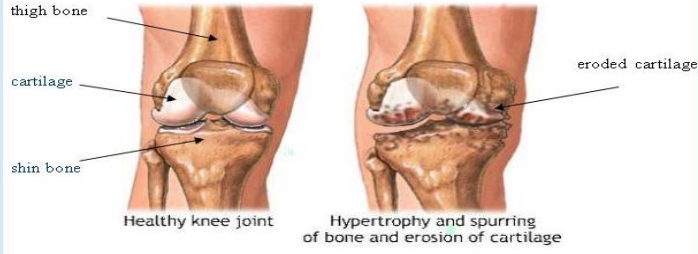

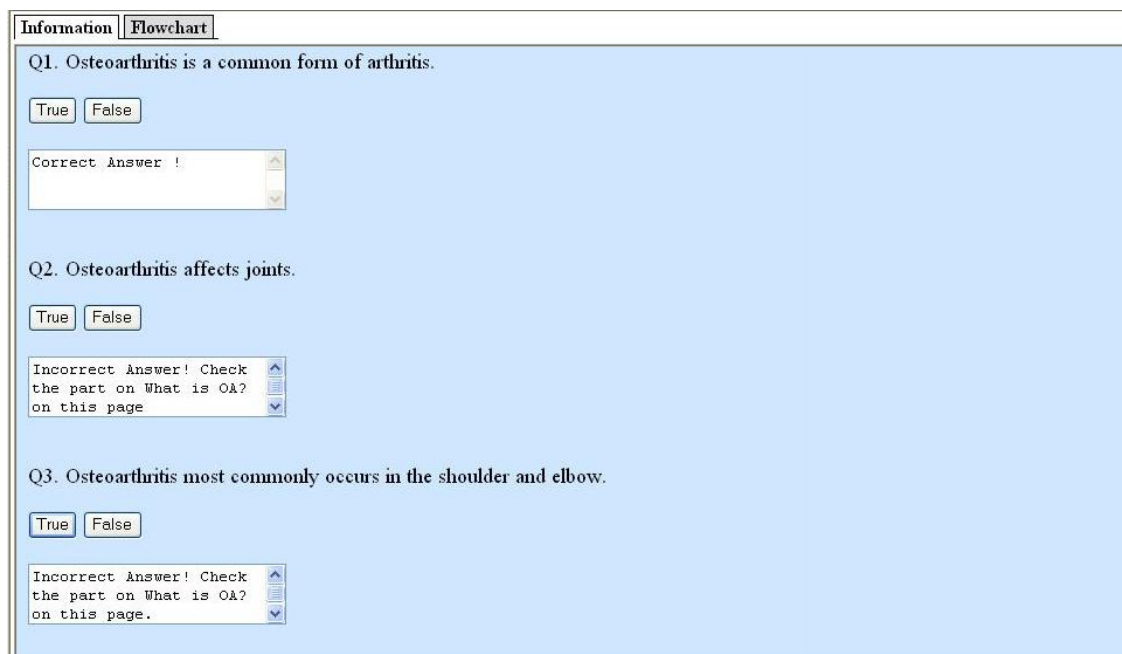**Figure 5: Example of "Test your knowledge" section**

Figure 6: Example of answers to "Test your knowledge" section

neural network. The Fourier transform creates a "fingerprint" of the image of a bone and the neural network performs classification using features passed to it by the Fourier transform. The method was tested in both the cases of osteoporosis and OA. It was found that misclassifications occurred and that this was mainly in the case of OA samples compared with normal samples. Two sets of results in [15] also indicated more difficulty in identification of the OA group. However, the tests were more successful in the case of osteoporosis.

Wrigley et al [16] describe the application of Matlab tools for producing movement biofeedback. The preliminary purpose is for teaching patients about modifying their gait for the reduction of knee loading when suffering from knee OA. The researchers have yet to determine the effectiveness of their system, so [16] covers the technicalities of the system as well as its performance. The researchers have learnt how to make the performance of this system a general success.

3. WEB GUIDE FUNCTIONALITY

A description of the functionality of the OA guide is now in order. The guide is composed of seven sections:

1. What is OA of hip and knee?

2. What can I do to help manage my OA of the hip or knee?

3. What does self-management mean?

4. Will exercise help my OA?

5. Can healthy eating help my OA?

6. What medications can I take to treat my OA?

7. Will surgery help my OA of hip or knee?

Thus, each section of the guide is answering a specific question that the patient may have about OA. The purpose of these particular seven sections for assisting the patient should be self-explanatory from the above section titles. We will cover these sections with representative content to give the reader an indication of what is found in the guide since not all content can be covered.

Figure 1 shows the first page that the patient sees after logging into the guide. This Figure shows the "home page" of the guide. Every section in the guide consists of a navigation pane on the left-hand side of a page (the area with the white background) and an information pane on the right-hand side (with a blue background). The navigation pane always contains a pull-down menu (as can be seen as the final content of the navigation pane in Figure 1) from which the

patient can navigate to any section of the guide. The navigation pane in the case of the guide home

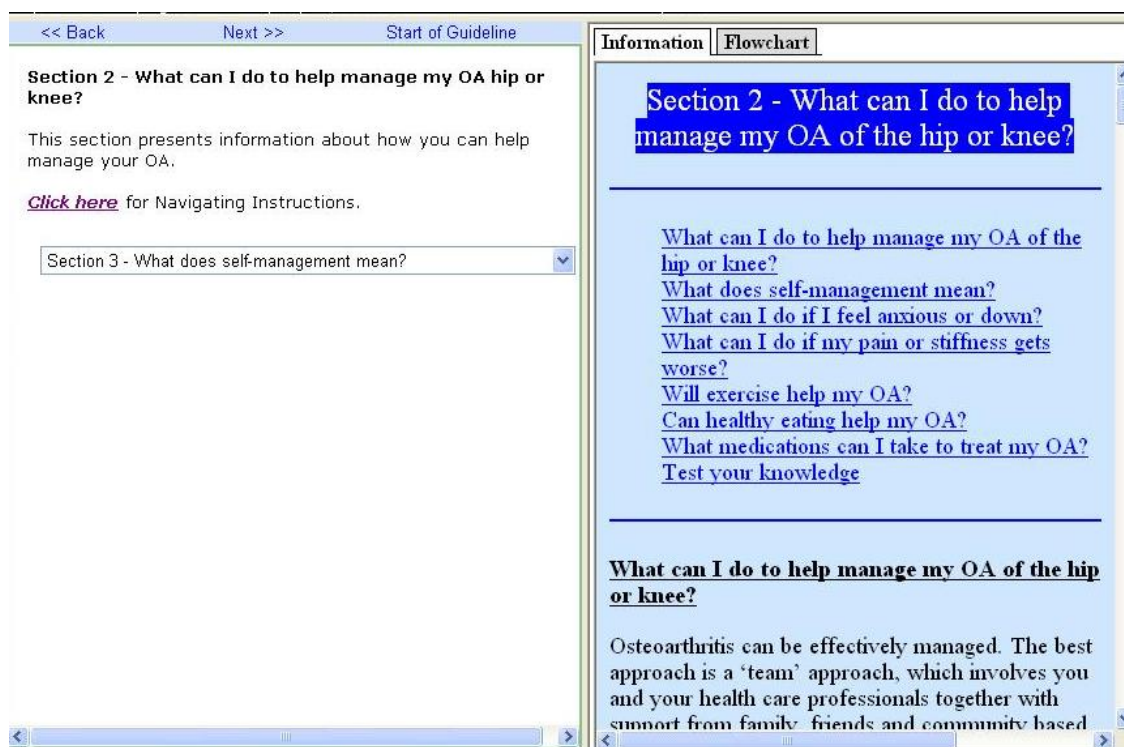home page contains "Living with Osteoarthritis", which explains what the guide is about. The

Figure 7: Section 2

page:

- ❑ welcomes the patient to the guide
- ❑ explains that there are seven sections that answer common questions about OA, and
- ❑ describes how to navigate the guide

The information pane in the case of the guide

information pane is by default shown on the right-hand side of any page. However, a developer could select from the tab above "Living with Osteoarthritis" to view the flowchart of all sections in the guide. This assists the developer to know where they are within the guide and where they can get to in the guide.
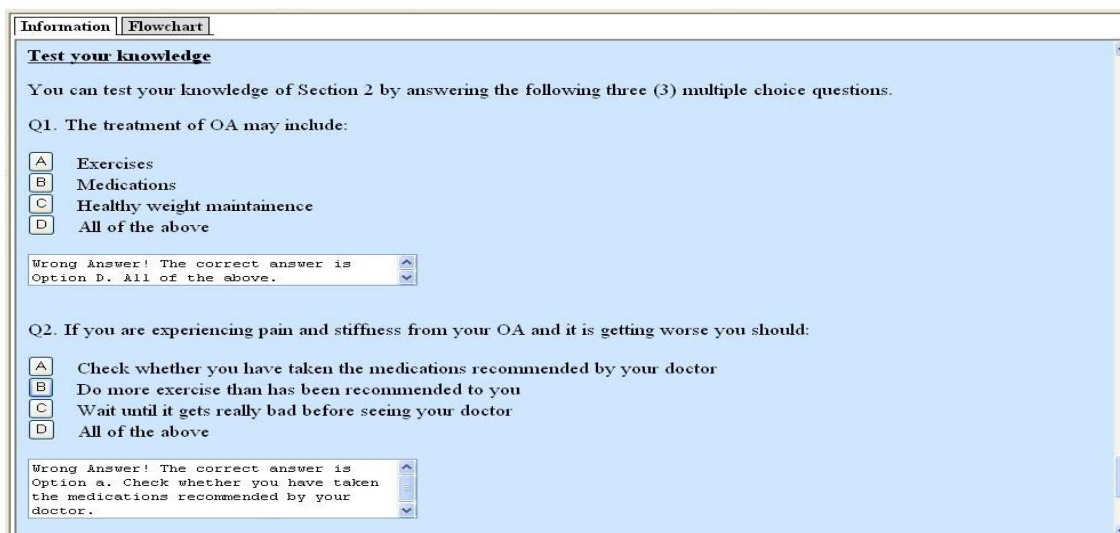

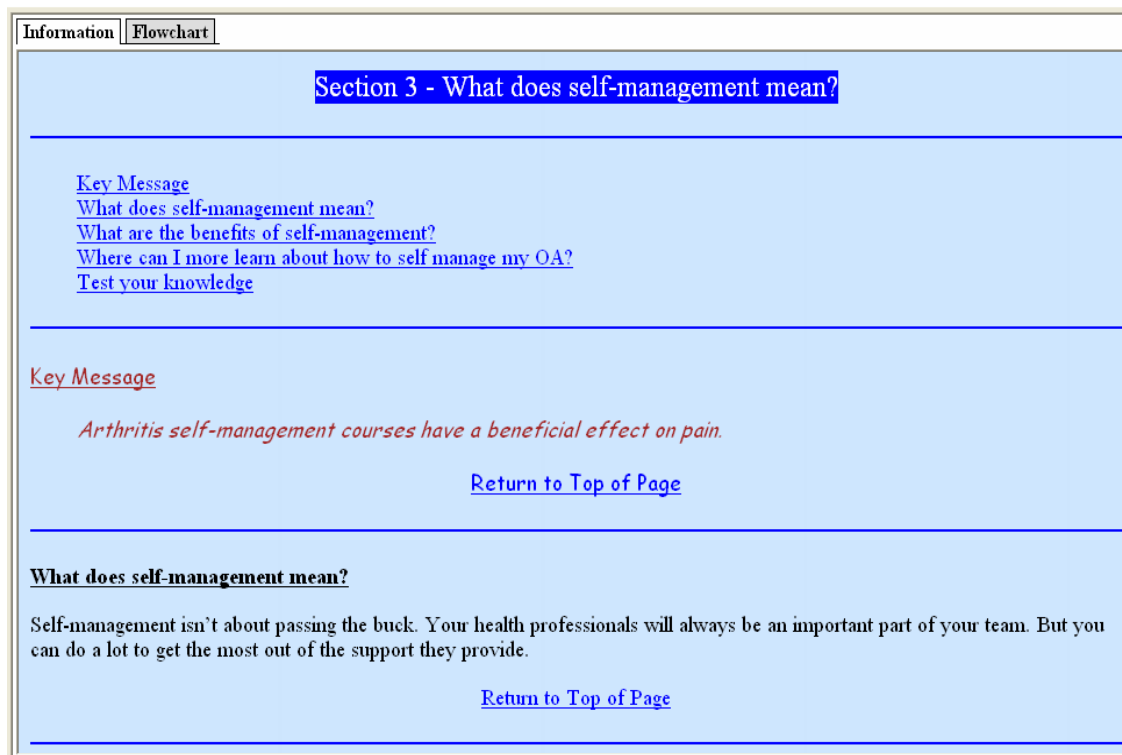**Figure 8: Example of multiple-choice "Test your knowledge" section**

If the patient selects the first section from the pull-down menu shown in Figure 1, they will see the page in Figure 2. The guide Web page is totally devoted to section 1, "What is OA of hip and knee?". The navigation pane for section 1 explains briefly what section 1 is about and its pull-down menu provides access by default to the next logical section in the guide (section 2). The information pane for section 1 contains basic questions and their answers relating to what is OA of hip and knee. Figure 3 shows an expansion of the information pane in Figure 2.

Figure 3 illustrates that underneath the heading of the information pane (in this case, "What is OA of hip and knee?") there is always an internal index within the pane. The first entry in this particular index is "What is OA?". By clicking on this internal link, the patient will be taken straight down to the first content sub-section in section 1 (seen at the bottom of Figure 3). To give the reader more of an understanding of what this particular section contains, Figure 4 shows further content of the "What is OA?". The reader can see that there is an explanation of what OA is along with a diagram. There are several such sub-sections in this information, which do not need to be covered. However, the last link in the index is "Test your knowledge" which will be explained here.

This is an example of seven "Test your knowledge" sub-sections that exist in the guide. Since the purpose of the guide is to educate patients, clearly to reinforce patient knowledge and assist them to know if they understand what they have learnt about their condition, it is useful to use such knowledge testing questions. Figure 5 shows the first two questions for this "What is OA?" section (actually question 3 can also be seen at the bottom, but its form is not shown). For each question, after the question is displayed:

- there are two buttons for the two possible responses to the question (i.e., one button for a true response and one button for a false response)

- there is a text box where feedback is given to the patient, i.e., either:

    o "Correct Answer !", or

    o "Incorrect Answer !" along with an indication of which sub-section in the section the patient should go back to in order to know why their response was wrong.

Figure 6 shows what happened when a hypothetical patient answered the first three

Figure 9: Section 3

questions. The answer to question 1 is correct whilst the answers to questions 2 and 3 are incorrect.

Returning to Figure 2, we see that the navigation menu is ready to take the patient to the second section, "What can I do to help manage my OA of the hip or knee?". When the patient takes this option, they see the Web page in Figure 7. This section will educate the patient in self-management of their OA condition. The right-hand part of the Figure shows the information pane of Section 2, including the internal index into the page.

Figure 8 shows the "Test your knowledge" sub-section for this section. This is the only "Test your knowledge" sub-section that is different from all the other "Test your knowledge" sub-sections in the OA guide in that it is a multiple-choice test as opposed to a True/False test.

Figure 8 shows the first two questions and the results after a hypothetical patient answered these questions. In the case of the first question, the patient pressed a button other than the button with the "D" option (i.e., the button with the "D" label). Therefore, the patient was informed that the correct answer was "D" and that "D" corresponds to the answer, "All of the above". Similarly, a wrong option is selected for question 2 and the patient is given the response shown in the text box for this question.
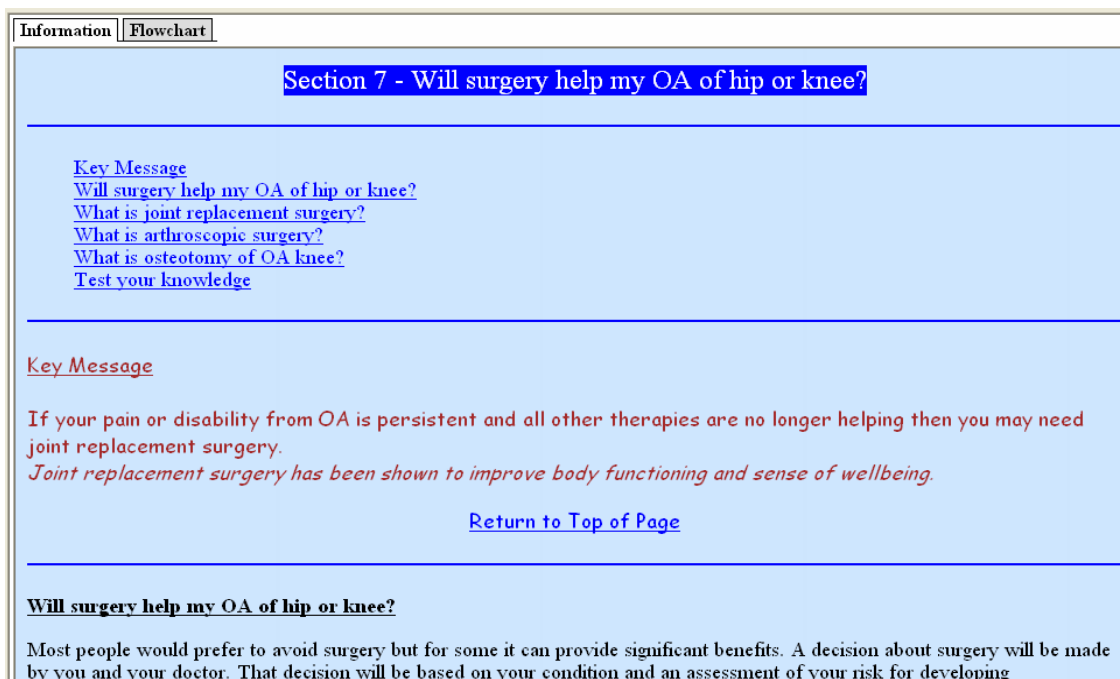
There are similar information panes for sections 3 to 7 in the OA guide. It would be repetitive to show all of the information panes for all these sections. Thus, Figure 9 and 10 display the information panes for section 3 and 7, respectively.

4. EXPERIMENTAL METHOD

The method used to evaluate the Web guide eliciting feedback from participants was that of heuristic evaluation [17]. Heuristic evaluation is a usability inspection technique for evaluating a user interface. Usability problems are detected by evaluators, who are human participants (and could be experts in the domain supported by the software) evaluating the user interface. In our case, two of the evaluators are clinicians (rheumatologists) who deal with patients suffering from OA, and one is a consumer with OA. Since these evaluators have knowledge in the area of OA hip and knee, they provide relevant feedback to a guide for their area.

Heuristic evaluation is a relevant method to our work because it allows us to utilise input into development of the system from experts (in our case, the experts are rheumatologists). It is these rheumatologists who are able to detect usability problems in the site (as indicated by [18]).

In addition to this, the guidelines of heuristic evaluation (i.e., "Visibility of system status",

Figure 10: Section 7

"Recognition rather than recall", "Match between the system and the real world", "Flexibility and efficiency of use", etc.) are exactly suited to evaluating a system like ours. Since the system should be used by a novice with basic computer skills, these guidelines assist greatly in detecting flaws and problems in a system that is important in educating patients about their condition. If fundamental difficulties exist in a Web guide for which the goal is to help patients in learning about and managing their condition, then it is clear that such a system is less useful in achieving this goal.

We used Jakob Nielsen's heuristics [17] to question participants about their experience with the guide. The responses, collected as handwritten data on the evaluation scripts (see Appendix), were used to determine improvements to the site.

5. EXPERIMENTAL RESULTS

The following are the results of analysis of the heuristic evaluation test scripts filled in by the three evaluators (two clinicians and one consumer with OA). Not all data entered onto each of the scripts in response to each and every heuristic could be expected to be highly relevant or useful, so only the most relevant data has been used to generate results. The results of this section are organised by the heuristics found in the script. As a reminder to the reader, the results below have been applied to the initial version of the guide and the user interfaces shown in Section 3 are the amended versions. The reader may view the script in the Appendix. Errors in writing of the data entered onto scripts (e.g., missing words, missing punctuation, etc.) have been retained in the quotes below.

Consistency and standards

This is heuristic (iv) of the script. Two participants found the consistency within the guide and the application of Web standards to the guide to be sufficient. However, one participant indicated:

> The availability of a test your knowledge feature could be more obvious ? have it as a link at bottom of each in the section rather than = the drop down menu. This would also make it clearer that each section has been completed.

Originally the "Test your knowledge" section was accessed via a pull-down menu. In response to this participant's suggestion, the section was made accessible via the link as shown in Figure 2.

Recognition rather than recall

This is heuristic (v) of the script. One participant stated that:

> Navigation is straightforward

and another participant stated:

> Once I got the hang of the navigation it was consistent throughout

However, one participant said:

> Well set out, but didn't use the left (white) page.

This last statement required further clarification as we were unsure as to how this was possible. The left page (the white page) would have been used by all participants to go from one web page to the next on the Web site. Based on the former two comments no further changes were made to the navigation.

Flexibility and efficiency of use

This is heuristic (vi) of the script. In terms of major feedback to this heuristic, a participant responded:

> I think inexperienced users would struggle with the navigation esp(ecially) the drop down menu & the linking to test your knowledge sections.

The change to access of the "Test your knowledge" sections was covered above in Sub-section B.

Aesthetic and minimalist design

This is heuristic (vii) of the script. One participant stated "*Links to more information maybe useful*" and another stated "*Found it clear & straight to the point*". The former participant's response does not suggest anything specific which can be improved in the guide. As well, the latter participant's response does not require any improvement at all to the guide. On the other hand, the remaining participant provided us with the following comment:

> There is a large amount of the {information} provided but this is appropriate. Use of key messages a good idea but not sure about having it

This clinician assessed that the quantity of information did not require reduction nor expansion, hence no change was made to the information provided. Also, the inclusion of very important points as "Key messages" (for instance, "Arthritis self-management courses have a beneficial effect on pain" in section 3 of the guide) was found to be a positive aspect but the

participant was unsure that these messages are absolutely vital in the guide.

Help

This is heuristic (viii) of the script. One participant responded that "*Help would be useful*" and another that "*It may help people*". However, the last participant indicated:

> Maybe useful to have the navigation instructions come up automatically at the beginning as otherwise many users will struggle through for a while before realising the help exists

This feedback was applied to what is now referred to as the "navigation pane", and the amended version can be seen in Figure 1.

6. CONCLUSION

This paper describes our Web-based patient guide for osteoarthritis (OA) of the hip and knee for educating patients about this condition. Patients are educated about various issues such as what is meant by OA of the hip and knee, if exercise will help the patient in any way given or what medications can be taken by the patient to help with this condition.

The paper also shows the functionality of the final version of the guide using a series of screen shots. Use of navigation, layout of pages, linking and so forth were covered.

Finally, the experimental method of using heuristic evaluation with clinicians and the major results subsequently arising from heuristic evaluation were described. Clinicians and a consumer with OA provided useful feedback regarding issues such as "Consistency and standards", "Recognition rather than recall" and "Flexibility and efficiency of use". This feedback was applied to the initial version of the guide to generate the design shown in this paper as the final version of the guide.

The potential for future work would involve carrying out further evaluation with more end-users, that is people with OA, using usability techniques other than heuristic evaluation. For instance, using think-aloud protocol or cognitive walkthrough. Also, further development of the site would be a possibility before deployment in the real-world setting.

7. ACKNOWLEDGEMENT

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APPENDIX

Heuristic Evaluation Test Script

The evaluators would have to evaluate the application individually and put down their comments to the developers, keeping in the mind the type of users that would be using the guideline. The evaluator needs to assess the web guideline against the heuristics given below. The evaluator should go through the guideline at least twice. The first pass would give the evaluator a general feel of the guideline, which would help the evaluator to concentrate on the specific elements of the guideline and compare the guideline to the heuristics when he performs the second pass through the guideline. The evaluator has to test whether the guideline complies with the objectives of each heuristic. The evaluator then puts down his comments/critiques and suggests a possible solution/approach to fix the problem.

i)   Visibility of system status

Objective: The system should be able to give feedback in reasonable time, so that the users know what is going on and where they are in the system.

Comments:

Possible approach/solution:

ii)   Match between system and the real world

Objective: The words, phrases and the idea put forth should be recognisable and common enough for the users to comprehend. A logical order of the flow of information should be maintained.

Comments:

Possible approach/solution:

iii)   User control and freedom

Objective: The users should be allowed to correct their mistake often made by selecting incorrect options or navigation links. They should be allowed to go back one step and also should be allowed to exit the current section to go back to the start page, at any stage.

Comments:

Possible approach/solution:

iv)   Consistency and standards

Objective: Standard conventions should be used, so that the users do not get confused whether two different notations (words, phrases, symbols, etc.) mean the same or have a different implication.

Comments:

Possible approach/solution:

v)   Recognition rather than recall

> *Objective*: The instructions for navigating through the system should be evident at every stage. The users do not have to remember the entire course on their way ahead.

Comments:

Possible approach/solution:

vi)   Flexibility and efficiency of use

Objective: Both experienced and inexperienced users should be able to use the system

Comments:

Possible approach/solution:

vii)   Aesthetic and minimalist design

Objective: The information provided should be just appropriate. The sections need not include irrelevant information or information more than necessary.

Comments:

Possible approach/solution:

viii)   Help

Objective: A section for 'Help' should be provided to guide the users in using the system.

Comments:

Possible approach/solution:

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