ABSTRACT
To better understand older adults’ perceptions and use of Web-based multimedia features particularly in health-related content areas, we conducted a comparative usability testing of three Web-based multimedia health tutorials – MedlinePlus Surgery Videos and MedlinePlus Interactive Tutorials both maintained by the National Institutes of Health (NIH), and Surgery Simulation (pseudo name) by a U.S.-based non-profit organization – with 10 older adults in February-March of 2010. Data were collected from interviews, surveys, and observation carried out in three consecutive sessions. In this paper we report a subset of the key findings from our qualitative data, focusing on literacy-related challenges participants encountered when using the three sites. These challenges reflect gaps between the computer, medical, and numerical literacy levels that designers expected users to have and the literacy levels that these users actually have. Based on these findings and the multimedia learning literature, we recommend design and training guidelines that may facilitate older adults’ learning and use of Web-based multimedia health tutorials.

Categories and Subject Descriptors
H.5.2 [Information Interfaces and Presentation]: User Interfaces – evaluation/methodology, interaction styles, theory and methods, user-centered design.

General Terms
Design, Human Factors.

Keywords
Multimedia, literacy, health tutorial, older adults.

1. INTRODUCTION
A multimedia document contains not only plain text but also “information in the form of graphics, audio, video, or movies” [1, p. 44]. A multimedia computer program includes “text along with at least one of the following: audio or sophisticated sound, music, video, photographs, 3-D graphics, animation, or high-resolution graphics” [2, p. 253]. With the development of technology, computer-based multimedia tutorials are increasingly being used in health education for medical students [3, 4], patients [5, 6] and the general public [7]. However, to date little is known about what multimedia features of Web-based health tutorials work and what do not work for older adults. Older adults generally have a great need for health information and services; yet, older adults also are more likely than younger adults to experience difficulties in using computers [8], including finding reliable health information on the Web [9]. Existing guidelines focus on designing senior-friendly Websites in general [10]. New guidelines are needed for designing Web-based multimedia health tutorials for older adults.

To begin to address this gap in the literature, we conducted a comparative usability testing of Web-based multimedia health tutorials by older adults in February-March of 2010. The primary aims of this study were to 1) compare the senior-friendliness of Web-based multimedia health tutorials; 2) generate preliminary data on older adults’ perceptions of and preferences for the multimedia features of Web-based health tutorials; and 3) explore the applicability of existing multimedia learning theories to the older population in an informal educational setting. Three Web sites were selected for testing in this study because they all 1) cover the topic of knee surgery, thus ensuring the topic consistence across the sites, 2) are from credible sources, thus ensuring the quality of the content on the site, and 3) are publicly available via the Web. These sites were: 1) MedlinePlus Surgery Videos (http://www.nlm.nih.gov/medlineplus/surgeryvideos.html) and 2) MedlinePlus Interactive Tutorials (http://www.nlm.nih.gov/medlineplus/tutorial.html) both maintained by the NIH, and 3) Surgery Simulation (pseudo name) developed by an U.S. non-profit organization (name of this site has been altered to avoid potential conflict). Key features of these sites are discussed below in context (see Results section). Situating our findings within the multimedia learning literature, we recommend design and training guidelines to facilitate older adults’ learning and use of Web-based multimedia health tutorials.

2. MULTIMEDIA LEARNING: THEORIES AND PRINCIPLES
Building onto and integrating the cognitive load theory [11], the dual-coding theory [12], and the working memory model [13-15], Richard Mayer has developed the Cognitive Theory of Multimedia Learning (CTML) [16]. The CTML holds that
multimedia presentations that consist of words (presented as written text or audio narration) and pictures (presented as static or animated graphics) foster deeper learning than single-medium presentations [16]. Building on the CTML, the modality principle [17, 18] argues that where verbal and pictorial information are necessary for understanding, verbal information should be presented in narrative rather than written form, because presenting verbal information in narrative form relieves cognitive load on the visual channel. The redundancy principle [19] suggests that, when only one sensory modality is required to convey understanding, using multiple sensory modalities imposes unnecessary cognitive load. The cognitive aging principle [20] is the only multimedia learning principle (that we are aware of) targeting specifically older learners. It holds that when learning novel information, older adults experience decreased performance in working memory. Properly designed multimedia presentations can effectively mitigate the effects of working memory declines.

Paas et al. [20] suggests two approaches to multimedia design for older adults: (1) learner controlled pacing and (2) part-whole sequencing of information. Learner controlled pacing allows learners to control the speed at which they progress through a multimedia presentation. Learner control is important because there are highly individualistic differences in older adults’ cognitive processing ability; learner controlled pacing is the only way to fully accommodate these differences. However, learner control also adds cognitive load, which may impair learning. A major challenge in designing learner controlled pacing is developing interactive tools that permit learner control while at the same time not adding undue cognitive load. The part-whole sequencing approach to multimedia design [20] addresses information overload by presenting select pieces of information prior to presenting the whole. The learner stores information about the pieces in long-term memory, which helps reduce cognitive load when viewing the whole presentation.

Existing theories and principles provide insights about designing Web-based multimedia health tutorials for older adults, though they focus primarily on younger learners in formal educational settings. Whether these theories and principles can be generalized to the older population in informal settings is yet to be answered.

3. METHODS

A total of ten older adults – all African Americans – participated in this study. Participants were between 61-83 years of age (M = 71.4, SD = 8.28). Seven of them were women. Seven participants had at least some college education. Three participants had less than one year of experience with the Internet; three had between 1-3 years and four had more than 5 years of Internet experience.

Participants were recruited from a research project that aims to facilitate older adults’ learning and use of electronic resources for reliable health information [21]. All participants signed the consent form (approved by the Institutional Review Board of the authors’ university) prior to participating in the project.

All three testing sessions took place in a public library. Participants were first guided to the home page of Site #1 (Note: the order of the sites being tested was altered to reduce potential bias). Participants were then instructed to explore the site independently for as long as 10 minutes. They were asked to “think aloud” during the testing. Note-takers wrote detailed observations into a set of recording forms. Recorded during each task were success (or failure) of completion and each participant’s remarks and session behaviors including misunderstandings and errors. Note-takers played a generally passive role during the testing – that is, they tried to avoid giving information on how to do a task. Instead, note-takers were instructed to ask participants to verbalize their problem, poke around a little, and, if participants got too frustrated or stuck, directed them to go on to the next task.

Upon the completion of the testing of Site #1, participants were given the quantitative post-test questionnaire to fill out; then, note-takers used the debriefing questionnaire to prompt and record qualitative feedback. These same steps were repeated for the testing of Site #2 and Site #3. Testing for each site lasted for approximately half an hour to 45 minutes.

Quantitative data were entered into SPSS for descriptive analysis and analysis of variance (ANOVA). Qualitative data were analyzed by using the techniques of microanalysis [22, p. 57].

4. RESULTS

The interviews, surveys, and observation yielded rich quantitative and qualitative data. These data reinforce each other and all suggest that the MedlinePlus Interactive Tutorial was the most popular and easiest to use, followed by Surgery Simulation. MedlinePlus Surgery Video was the least popular and most difficult to use. Analysis of the qualitative data revealed several key themes that can help explain the relative popularity and usability of these multimedia tutorials. Due to space limit, in this paper we focus on one of these key themes: gaps between the literacy levels that designers expected users to have and the literacy levels that the users actually have. This theme includes two sub-themes: 1) gaps in expected and actual computer literacy; and 2) gaps in medical and numerical literacy. (Other findings will be reported elsewhere; contact the first author for updates.)

4.1 Gap 1: Computer Literacy

This gap can be seen in several interactive features that caused great confusion among the participants.

4.1.1 The “ghost” control bar

The control menu of the Surgery Video is not visible unless the mouse cursor is moved to the video section; even so, the control menu disappears after only a few seconds. To bring it out again (for another few seconds), the user would have to first move the cursor out of the video area, and then move it back into the video area. These operations require that the user 1) has knowledge about what to do at each step, and 2) is comfortable with manipulating the mouse constantly. Neither is the case for older computer users, unfortunately. Not surprisingly, this “ghost control bar” feature was really not popular and caused great difficulties and frustrations – it was criticized by all of the participants. For instance, Mr. E., a retired surgeon and one of the more advanced computer users among the participants, felt that the technology level of the video controls on this site was difficult for “average users”; he would like to have the controls stay on the screen and “not disappear like a ghost.”

4.1.2 Symbols

Multiple control buttons of the Surgery Video appear as symbols with no accompanying text. For instance, the pause function is signaled with a button with two vertical, parallel lines (Figure 1).
Figure 1. The Pause button on the Surgery Video site.

While this pause symbol is the one commonly used on electronics, it still caused much confusion among the participants – it was not obvious to any of them what it means. For instance, Ms. V could not figure out how to pause the video. When the note-taker pointed out the pause symbol on the screen, she replied, with surprise: “But that doesn’t say ‘pause’; how would I know?”

Further complicating the situation is that the word “Pause” does not appear – briefly and as a cue rather than a clickable element – when the mouse cursor is placed over the symbol (and after a few seconds, the word disappears; the user would need to move the mouse cursor away, then back, in order to see the word appear again). This caused even more confusion and frustration. Mr. W initially looked extensively for a pause button on the keyboard without realizing that he could use the mouse to perform the task on the computer screen. When reminded to perform the task on the screen, he got confused with the design of the button: When the mouse is placed over the pause button, a cue (i.e., the word “pause”) pops up to indicate that the button is the “pause” button. When this occurred, Mr. W repeatedly tried to click on the cue – the word “pause” – rather than the pause button right below the word. He stated that it was “very confusing” that you could not click the word stating “pause” to make the screen pause.

Similarly, participants had trouble with the full screen button. This function is illustrated with a symbol alone and does not include the words “Full Screen” (Figure 2).

Figure 2. The Full Screen button on Surgery Video.

This can be confusing to someone who is not familiar with the meaning of the symbol. For instance, Mr. W could not complete the task of changing the video to full screen. When the note-taker demonstrated the full screen button, Mr. W stated that there was no way he would understand that the four arrows would switch the video to full screen, despite his ability to clearly see the icon.

Mr. W also failed to understand the symbols representing the video’s progression (Figure 3).

Figure 3. The symbols representing the video’s progression on the Surgery Video site.

Because the surgery video lasts for about an hour, the dot indicating position progresses quite slowly, making it appear almost static. While Mr. W clearly noticed the dot, he did not demonstrate an understanding of its meaning. When asked to move the video forward, he did not know that he could do so by manipulating the dot (plus the dot was so small that it would have been difficult to manipulate even if he knew about this feature).

Participants also had trouble with the “Play” button, even when it is prominently displayed in the middle of the screen (Figure 4).

Figure 4. A screen shot of Surgery Video; the Play button is prominently displayed in the screen.

While they could clearly see this button, participants did not understand that they could click the button to re-start the video, suggesting that the meaning of this symbol is not intuitively obvious to these participants.

Mr. J found it confusing that the symbol for “play” was in the middle of the screen while the video was not playing: He associates the play symbol with the video playing, it is confusing when the play symbol is prominently featured while the video is currently paused. Mr. J indicated that his biggest challenge with the Surgery Video site was “learning the symbols.” He stated that the symbols were not “self-explanatory” and that he needed someone to explain to him what the symbols meant. Mr. J was not eager to try clicking on a symbol just to learn its purpose.

This reluctance of engaging in trial-and-error is also evident in other participants. For instance, Mr. W is hesitant to perform an action unless explicitly instructed to do so. Ms. F did not initially see the button for “Surgery Videos” even though it was quite prominently displayed on the screen (or perhaps she saw it but did not know what a button is). When the note-taker promoted her if she saw anything on the screen that said surgery video, she then pointed to the button and said, “It’s probably this [button] here.” Even so, she still did not start moving the mouse to click on it.

Out of the three sites, Mr. W liked Interactive Tutorial the most; a likely reason is that this Tutorial gives the user very discrete written and audio instructions about when it is appropriate – and exactly what to do/where to click – to move on to the next task. For instance, the instructions inform the user to navigate to the next step by clicking on a large right arrow (Figure 5).

Figure 5. The symbol on Interactive Tutorial indicating navigating to the next step.

This simplified interactivity complemented the way Mr. W interacts with computers quite well. He showed a great deal of comfort with the computer when giving continual, ease to follow instruction on what to do next.

Similarly, Mr. J was comfortable using the symbols in the Interactive Tutorial, presumably because he found those symbols more self-explanatory. It is also possible that, Mr. J had learned quickly from the testing of the Surgery Video site and was able to apply what he had just learned to the Interactive Tutorial site – he did state that, in evaluating the Surgery Video, he would be able to use the site in the future once the symbols were explained. If this is the case, then perhaps an educational intervention (e.g., a tutorial for the multimedia symbols) might be a quicker and lower cost solution than having to re-design the site.
Ms. A liked that the volume button in the Interactive Tutorial actually said “volume” in text (Figure 6 below, left picture); in contrast, the volume button for the Surgery Video simply shows a speaker (middle picture) and was not intuitively clear what it meant (also, it was small, difficult to see): When asked, Ms. A indicated that she did not initially understand that the button was supposed to represent a speaker. She felt the Interactive Tutorial volume button was much more clear than the Surgery Video volume button. Similarly, on the Surgery Simulation site, Ms. A was confused about how to turn the sound on and off – the volume button on this site also did not contain text stating “volume” or “sound” next to it (right picture).

Figure 6. Audio on/off buttons on Interactive Tutorial (left), Surgery Video (middle), and Surgery Simulation (right).

4.1.3 New Windows
On all three sites, when clicking on something, it is likely to open up a new window that appears on top of an existing one. Participants got confused by multiple windows opening from the main page. For instance, when clicking on the “Text Summary” button in the Interactive Tutorial, a new window pops up and blocks almost the entire previous page (Figure 7).

Figure 7. A screen shot of Interactive Tutorial, showing the new window blocking the previous window.

There is no sign or cue on the new window directing the user back to the previous page. To do so, the user would need to either close the new window, or click on the tab of the previous window at the bottom of the screen. Yet, for these older adults, neither option is intuitively obvious. This is true even for older adults like Mr. E who has more computer experience than the other participants. This finding suggests that, while it may have become an intuition for more experienced users such as many younger people to handle multiple windows on the computer, it is not necessarily the case for less experienced users like older adults.

An added burden is that, the new window may be wordy and distracting. The Surgery Video site has transcripts in PDF format that open up as separate windows. These transcripts are lengthy and crowded with text (with no image or picture). For instance, the transcript of the Computer-Assisted Total Knee Replacement video (by the Wake Forest University Baptist Medical Center, Winston-Salem, NC; May 2, 2008) is a 15-page PDF file with 11,000 words. How useful can this kind of transcript be and for whom? Ms. R suggested that there should be subtitles to go with each step/screen instead. This way, people who have hearing problems can watch the video and read the text at the same time. Further, Ms. R suggested that the Surgery Video site could be improved by adding more arrows or highlights to the video screens: “I want to see more pictures with the reading, with arrows, to highlight certain words right in the area, for the proper names, so that you can see what’s going on.” This suggests that while having subtitles can be better than having just text-based transcripts, perhaps an even better approach is to add arrows or words to highlight the precise area that the narrator is speaking of so that the user knows exactly where to focus on at each step.

4.1.4 Subtitles
While subtitles may be preferable compared with large blocks of text, without proper design, subtitles can cause confusion as well. For instance, when clicking the “Subtitles” button on Surgery Simulation, the interface shows no change, thus no indication that subtitles have been turned on or off. The only way to tell that subtitles are on is if they appear when the narrator speaks. This is not obvious. Several participants repeatedly clicked on the “Subtitle” button to see if anything changes, and got frustrated when nothing happened. A possible solution is to add a sign to the page to indicate whether the subtitles are on or off.

4.1.5 Enlarge photos
On the Surgery Simulation site, there is a section with thumbnail images of Surgery Photos, which, when clicked on, can lead to enlarged images. Yet, there is no cue on how to enlarge these images, or even indicating this option.

4.1.6 Site Map
The meaning of the phrase “Activity Site Map” on Surgery Simulation is not intuitively obvious. Participants saw the phrase however did not understand what it’s for. This lack of knowledge about the meaning of this phrase, coupled with participants’ reluctance to click around or trial-and-error to find out what it means, made it difficult for them to make good use of this feature.

4.1.7 Repeat vs. Back
The Repeat button on Interactive Tutorial was presented with both the text (the word “Repeat”) and a symbol (Figure 8).

Figure 8. The Repeat button on Interactive Tutorial.

However, the exact function of this button was not clear to the participants – and thus the button might be easily overlooked. For instance, when asked to “Repeat any page” on this site, Ms. V did not seem to see the Repeat button. After the note-taker pointed out the button, she got somewhat defensive: “I had no idea. I didn’t pay attention to it. I guess I was just focusing on going forward.” After clicking on the Repeat button, she said: “So this does the same as the ‘Back’ arrow [on the browser’s control bar].” She did not understand that these are two different functions: with the Repeat function, the program starts over with the same slide (the present slide) while with the Back function the program goes back one slide and starts over from that previous slide.
4.1.8 Full screen video vs. Maximize the Web browser window

Another major confusion among the participants was the adjusting the video to full screen feature versus the maximizing a Web browser window feature. For instance, both Ms. V and Ms. A got confused with these two functions; when asked to change the video to “full screen”, they clicked on the maximize button on the Web browser to maximize the Web page instead.

4.2 Gap 2: Medical and numerical literacy

4.2.1 Prior medical knowledge

The Surgery Simulation site involves more interactivity than the other two sites; however, much of its interactivity requires knowledge that is not covered in the program. This may have at least partly contributed to its less popularity and usability than the Interactive Tutorial. In particular, Surgery Simulation requires prior medical knowledge: For instance, at the beginning of the program, there is a step where the X-Ray images of the left and right knees of a patient are displayed, and the “virtual doctor” asks verbally: “Which knee do you think needs surgery?” Then, a visual cue appears and instructs the user to “Click the knee you think needs surgery.” However, there is no prior information in the previous (or remaining) steps of the program about what a normal versus damaged knee should look like. To answer this quiz correctly, the user would need to have sufficient prior medical knowledge to know what a normal versus damaged knee should look like on X-Ray. This is problematic: having a quiz without first explaining the material can be confusing and make the user think that they missed key components of the activity.

For instance, this made it difficult for Mr. J to accurately answer the quiz questions (he said “I don’t know!”). Ms. R also had difficulty figuring out what she was supposed to do when the X-Ray showed up – she wasn’t sure which knee she had to click on. Even Mr. E, a retired surgeon, felt that the quizzes in Surgery Simulation were too advanced – particularly because the quiz answers were not even covered in the tutorial: e.g., he pointed out that there was no guidance when asking what normal knee looks like; the site developers assumed the user knew.

When the program indicated that the user should pick up the bone saw to perform the operation, Ms. V said, “I don’t know how to use this instrument.” After staring at the screen for a few more seconds, she repeated: “I don’t know what to do.” At other stages, she made similar comments: “I feel like I’m a novice... I don’t know what I’m doing... Are we supposed to know how to reshape a bone [since the program did not provide any training on how to do that]?” When asked to summarize her experience with the Surgery Simulation site, Ms. V said: “I liked it. But it’s the kind of website I need practice. It was very interesting. They ask you to cut the bone, but they don’t have markers where to cut, as if you knew. That would have been helpful.” She further stated this point when asked what she liked least about the site: “It didn’t have pointers to where you are supposed to go, to cut.”

Ms. F commented that Surgery Simulation was “Okay for someone in biology; [one] must know knee parts of the body, can’t know if no background.” She said she “needed help from the beginning; [it was] not self-explanatory how to use tools and what to do.” What she liked least about this site was the “technical aspects, need [to provide] some information for people who do not have technical background.” She suggested that, to improve, the site should “at the beginning explain various parts of the body and their location so that anyone doing surgery would be able to follow instructions of the surgeon” and particularly it should have “some instruction about how to ‘grab’ tools and use site tools.”

Ms. A also got lost in the instructions of the knee surgery simulation that used many medical terms. For instance, in the ‘Menger’ step where cutting of the bone needs to be done, she got lost – she did not know where to cut the bones because there were no directions or signs mentioned. She clicked four times but knew she had to cut more, because the instrument “would not go away.” Ms. A kept moving the instrument around, including trying to put it below the main screen and put it back in the tool bar. But the instrument was still there, making her realize she had more to do.

4.2.2 Numerical literacy

In addition to medical knowledge, Surgery Simulation requires other types of knowledge – that are also not covered in the program. In particular, at one point, the user is instructed to “Use your mouse to click and drag the foot handle so the leg is at a 90 degree angle.” This step requires the user clicking inside the target icon, holding the mouse left button, and then dragging the mouse towards a right-up direction in order to place the leg at a 90 degrees angle. These movements were not intuitively clear and required multiple types of knowledge and skills including precisely moving the mouse and understanding what “a 90 degree angle” means (which may be difficult for users with insufficient numerical literacy). This step was the most difficult one for Mr. J, who, for the first and only time during the testing session, gave up trying to figure it out on his own and, exasperatedly, he said, loudly while laughing awkwardly, “Alright, help!” At the end of the testing of the Surgery Simulation site, when asked about what he thought about it, Mr J. responded: “This one was kind of...ha, ha, ha...I enjoyed it...all of a sudden it was a challenge...more of a challenge so I didn’t get much out of it...it wasn’t crystal clear what to do next...not knowing the surgery procedures.”

4.2.3 Designing for the proper literacy level

Despite these challenging aspects of Surgery Simulation that required much prior knowledge and skills, on this site there was still a good example of designing for the proper literacy level. At an early step of the Surgery Simulation tutorial, the user is asked to use the marker to write down his or her initials, which is something anyone who has professional experience will do automatically. Another reason is that it is justified (the narrator explains this is to make sure the surgeon won’t operate on the wrong knee, something that does happen as reported in the media). Another reason is that this exercise does not require any skill unique to the medical professionals – it only requires the user to pick up a marker and write down his or her initials, which is something anyone who has the very basic literacy skills does all the time (in comparison, most of the other interactive steps require the user to have quite advanced medical knowledge and skills).

5. DISCUSSION

Designers of new technology tend to be younger adults who may have little understanding of age-related differences and how these differences can affect technology adoption and use [23-26]. The findings of this study reveal serious gaps between the literacy levels that designers expect their users to have and those that the
users actually have. While many of the operations (e.g., recognizing the symbols, handling multiple windows, enlarging photos) may have become almost “intuitions” for designers and more experienced Web users, this is not the case for less experienced users such as the older adults who participated in this study. The findings point out the importance of 1) taking into consideration the unique literacy levels of less experienced users and 2) providing age-appropriate training to bridge the literacy gaps between the expected and actual literacy levels.

The cognitive aging principle [20] suggests that multimedia presentations, when designed properly, can effectively mitigate age-related cognitive changes in older adults. An important approach to designing age-appropriate multimedia programs is to ensure learner controlled pacing – through proper interactivity – so that the learners can control the speed of learning at a rate compatible with their own learning styles and abilities. Unfortunately, learner controlled pacing was not well integrated in many of the multimedia features of the sites we tested. In particular, the “ghost” control bar on Surgery Video almost seemed like being deliberately designed to discourage user control of the pacing. In comparison, Interactive Tutorial and Surgery Simulation both feature more learner controlled pacing. However, Surgery Simulation appeared to have given the user too much control that it became a burden on the user: developers of this tutorial may have set high expectations for the learner’s prior knowledge and skills. As such, Surgery Simulation added cognitive load to the user, which may at least partially explain its less popularity and usability than Interactive Tutorial.

One type of cognitive load is extraneous load, or the load on working memory when interacting with the instructional material; as working memory has limited capacity to process and store information, it is necessary to keep extraneous load low [11, 27]. Our study found that both Surgery Simulation and Surgery Video require extensive knowledge and skills not covered in the instructions. This extraneous load adds extra burden to working memory, making it more difficult for the user to understand and use the site. To reduce such extraneous load, it is important to incorporate prior knowledge into the instructional design. This can reduce learners’ extra efforts to understand and navigate the new learning materials and thus minimizing the extraneous load associated with the learning experience [27]. Empirical studies provide support for this approach [28-30]. Note though, these prior studies involved medical students in formal educational settings while our study involved older adults in an informal setting. Our findings provide evidence for the generalizability of the cognitive load theory to the older population.

In developing effective multimedia programs, Najjar [31] suggests that the focus should be on 1) the characteristics of the learning materials (e.g., presenting verbal and pictorial information simultaneously), 2) the learner (e.g., using multimedia with novices), and 3) the learning task (e.g., encouraging the learner’s use of the newly acquired information). Though Najjar [31] does not specifically target the older population, he proposes that educational multimedia should be used particularly with learners who have low prior knowledge in the domain area. This matches well with the characteristics of our study participants.

The prior knowledge principle in multimedia learning [32] suggests that design principles vary in effectiveness depending on the prior knowledge of the learner. Design principles that aid learners with low prior knowledge may inhibit learners with high prior knowledge. This is because high knowledge learners must reconcile instructional explanations of information with information already stored in prior knowledge, creating an undue load on working memory. Therefore, health tutorials may vary in effectiveness depending on different learners’ prior levels of health knowledge. Soto Mas, Plass, Kane and Papenfuss [33] suggest that multimedia health education programs should provide different multimedia choices and allow the learners to choose any combination of media format that can support their learning abilities, styles and preferences. Incorporating different levels of interactivity into one tutorial may be a good way to ensure proper controlled pacing by different learners to accommodate different abilities and literacy levels.

Nielsen and Schaefer [34] examined sound effects as an interface element in a computer-based paint program, and found that the presence of functionally redundant sound effects were distracting to the older users, likely because they increased cognitive load for the older users. In our study, we also found that our participants did not appreciate the sound effects embedded in the Surgery Simulation tutorial (e.g., the noises occurred when sawing the bone). This suggests that, when designing multimedia tutorials for older adults, it is important to not include unnecessary multimedia features that may impose undue cognitive load.

Morrell, Park and Poon [35] compared the effects of text-only versus text-plus-symbol labeling on older and younger adults’ comprehension of prescription information. They found that older adults tend to remember more information when the medical label is in text-only format while younger adults benefit more from the text-plus-symbol format. In our study, we also found that older adults seem to prefer text over symbols: when a clickable element (e.g., pause) is presented as a symbol alone, it is difficult for the older users to recognize or understand it. In comparison, when a clickable element is presented with a symbol and accompanying text (e.g., the volume control button in the Interactive Tutorial), it is easier for these older adults to recognize and use it.

Using text-only clickables is supported by design principles based on Mayer’s CTML [16]. The coherence principle [36] suggests that removing unnecessary words or pictures reduces extraneous cognitive load. The coherence principle suggests avoiding abstract symbols that require additional explanatory text: Where text is sufficient to explain the purpose of a clickable element, adding symbols may serve to increase cognitive load. For example, in this study, the pause symbol used in Surgery Video required explanatory text to make the meaning of the symbol clear to the older adults. A better approach is simply using the text “Pause” to convey the meaning, and not demand additional cognitive load to comprehend an unfamiliar symbol.

Sufficient numeracy skills are important for health communication and decision-making [37]. Insufficient understanding of numerical information can lead to problematic medical decision, inaccurate perceptions of health risks, and miscommunication between patients and physicians [37-39]. To help the general public better comprehend numerical information in health decision-making, Apter et al. [37] propose a set of recommendations for presenting numerical concepts, including simplifying mathematical constructs, using appropriate formats of graphs with proper explanations, and repeating the instruction to reinforce important messages. These recommendations can be
useful for developing multimedia health tutorials. For instance, our participants found it difficult to understand the numerical information “90 degree angle” presented in one step of the knee surgery of Surgery Simulation. To facilitate user understanding, a graph showing a leg in a 90-degree angle can be added to the page. Also, the instruction can be repeated several times in order to reinforce an important message to the user. These strategies can help present numerical information more effectively to avoid adding cognitive load to the user’s working memory.

5.1 Senior-friendly guidelines
Based on the findings of this comparative usability testing study and building onto the multimedia learning literature, we recommend the following design and training guidelines for promoting effective multimedia learning among older adults, particularly in health-oriented content areas.

5.1.1 Design guidelines
- Control bar: Make the control bar prominent so that the user can easily see, understand, and use it to control the speed at which he or she is going through the program;
- Symbols: Use both text and symbol (e.g., having a phrase like “Click to Re-start Video” or “Click Here to Resume Video” to accompany the Play button), or text alone, to indicate the function of a clickable element; do not use a symbol alone if its meaning is not self-explanatory to users of various literacy levels;
- New Windows: Avoid new windows that block the previous window; if this is unavailable, at least design a built-in link (e.g., a clickable button) and place it in a prominent position in the new window to indicate how to close the new window to return to the previous window or navigate to the next step;
- Subtitles: Add a sign to every page (e.g., a button, bar, flag) to indicate whether the subtitles are currently on or off (and how to switch between on and off);
- Enlarge photos: Add clear instructions (e.g., “Click on a photo to see a larger photo”) to indicate that a larger version of the photo is available, and how to do so;
- Site Map: Use an alternative phrase to better convey what this feature means (e.g., “Video Sections” or “Table of Contents”); and
- Prior knowledge: Avoid having interactive features that require extensive prior knowledge and skills about computers, medicine, and numeracy.

5.1.2 Training guidelines
- Clickables: Provide a list of the clickables to prepare the users about the clickable elements of multimedia sites; help the users become familiar with the meaning and functions of symbols commonly used in multimedia programs;
- Repeat versus Back: Explain clearly the differences between “repeat” and “back”; and
- Full screen video vs. maximizing the Web browser window: Explain clearly the differences between adjusting a video to full screen and maximizing the Web browser window, and how to accomplish each.

6. Conclusion
This usability study of three Web-based multimedia health tutorials identified a number of challenges older adults encountered when using these tutorials. The challenges reported in this paper reflect gaps between the literacy levels that designer expected users to have and the literacy levels that these older users actually have. We recommend design guidelines that may help developers to design effective multimedia programs to facilitate older adults’ use of Web-based tutorials in general and multimedia health tutorials in particular. We also recommend training guidelines to help educators and practitioners to develop and provide age-appropriate training to help older adults make better use of multimedia health tutorials.

In future research, we will investigate further the key issues identified in this study: e.g., the best method for utilizing text and symbols; the effects of various multimedia features on different populations (e.g., older versus younger adults).

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