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When Only Boolean Knowledge Can Save the World from Alien Invaders: The Planning and Implementation of "Invasion of the And-Ors", a Flash-based Boolean Search Tutorial

Abstract: Describes an interactive, engaging, web-based tutorial and Alien Invaders-type game to teach Boolean searching techniques. The tutorial was designed using the personas method, which emphasizes diverse needs and learning styles of users. Active learning principles were used throughout to take advantage of the dynamic and interactive capabilities of Web media.
Résumé:

1. Introduction

Information literacy skills are increasingly recognized by educational institutions as vital to the success of their students (ACRL 2003). Part of this education includes teaching students about Boolean searching logic. Ways of teaching Boolean searching have changed little over time, even and especially in the digital environment. Online tutorials usually teach Boolean searching using the static techniques seen in traditional classroom instruction. This is a typical but ineffective strategy of simply repackaging traditional instruction and placing it in a digital environment (Schroeder and Spannagel 2006).

Our review of online tutorials, including the renowned Texas Information Literacy Tutorial, found that they overwhelmingly teach Boolean searching through a series of simplistic, static Venn diagrams showing overlapping memberships in sets, and also through tables showing changing numbers of items retrieved or written descriptions. This is particularly disquieting since other research has shown modern undergraduates and young adults often have a falsely high perception of their information literacy skills, to be resistant to learning information literacy through text-based methods, and a low tolerance for "boring" instruction (Bromham and Oprandi 2006; Brown, Murphy and Nanny 2003; Manuel 2002; Valenza 2006). Current online tutorials are not exploiting the dynamic and interactive capabilities of Web media which can effectively attract and engage their intended users to learn Boolean searching.

Our research goal was to meet this information literacy need: to create a highly accessible, interactive, engaging, web-based information literacy skills tutorial that teaches university students and other users about Boolean searching. The design of tutorial was to be driven by proven educational and Web design techniques and the tutorial would be evaluated for its effectiveness. This paper will describe the creation of "Invasion of the And-Ors", the resulting interactive Boolean searching tutorial, and describe current research plans.

1.1 Active Learning

One of the main concerns in the design of the project was the need for developing an active learning component. Active learning is a "how to learn" concept rather than simply a "what to learn" concept (Petress 2008, 569). It develops higher-order thinking skills (i.e. synthesizing and evaluating), not simple memorization (Wolfe 2006). It "requires students to make decisions, see the outcomes, and adapt or react to their decisions, (McKeachie, 2002) [which] can stimulate curiosity and boost self-confidence" (Wolfe 2006, 78). Active learning encourages students to learn in a style that suits them best, allowing different learning styles to be incorporated into curriculum design (Wolfe 2006, 79).

Extensive research has been done on the subject that has shown numerous benefits of this style of learning, particularly when based in electronic environments. This method of learning has been shown to be more satisfying, fun, and imparting of student self-confidence than traditional styles of learning (Petress 2008). When done correctly, it also leads to enhanced student engagement and communication (Schrand 2008, 81). Barak has shown that active learning boosts student performance and interest, increases student satisfaction and raises student conceptual understanding (2007). Ives et al.'s student survey research suggests that there is a correlation between technology, active learning and perceived course effectiveness (2005). Additionally, it has been shown that active learning has a positive effect on how students perceive their institutions to care about their welfare (Braxton 2008). Thus, active learning benefits both students and their institution and the student.

There are many effective methods to incorporate active learning into instruction. Bodie et al. argue that the "best way to teach complex material is to break it into small, manageable units or bits of information" (2006, 121). Levels of engagement are increased when students are given a clearly defined task (Schrand 2008). Successful active learning allows students to participate, act, react and reflect (Nirmalakhandan et al. 2007). Additionally, the most effective active learning exercises contain an element of repetition. Repeating concepts has the impact of reinforced learning and helping students make connections with other material (Bodie et al. 2006; Nirmalakhandan et al. 2007).

The best practices for active learning that takes place specifically in online environments do differ from active learning in traditional environments. However, in most cases, e-learning simply repackages traditional curriculum without harnessing the power of the digital environment (Schroeder and Spannagel 2006). Researchers have found that student satisfaction is higher with interactive online content, rather than text-based online content (Bromham and Oprandi 2006). It makes sense, then, that interactive online learning modules are accessed more frequently than more static instruction, such as downloadable PowerPoint presentations or PDFs (Bromham and Oprandi 23). The length of these modules is important, with Chung and Chen's study discovering that online interactive instruction should be limited to thirty minutes or less (2007).

Research has proven that communication is an important aspect of effective active learning, both at the student-to-student and student-to-instructor levels. Active learning in an electronic environment is made more effective when in-person instruction is integrated into learning (Bromham and Oprandi 2006; Eriksen 2004) and when it is situated in a larger learning environment (Hutchings et al. 2007). The in-person support figure acts as

a motivator and a resource (Petress 2008). Some scholars have suggested that online learning environments should have interaction and feedback integrated into them (Hutchings et al. 2007).

1.2 Information Literacy Education

There is a current trend toward information literacy being moved online. A recent longitudinal study of instruction practices in Canadian academic libraries revealed that information technology is increasingly used by instructors to guide students toward a more critical understanding of information, as well as being more of a focus of instruction (Julien 2005, 298).

Due to the excitement caused by the Internet's first coming into widespread use, established instructional principles tended to be momentarily forgotten. In her 1999 study on whether good library instruction practices were making the jump to web-based information literacy instruction, Nancy H. Dewald found that most of the tutorials she examined were deficient in course-relatedness, active learning, collaborative learning, clear objectives, teaching concepts instead of just mechanics and the option for asking the librarian for further help – elements of what she defines as “good” library instruction (Dewald 1999).

More recent literature, however, has featured examples of web-based literacy instruction that are developed with a consciousness of sound pedagogy. At Wake Forest University, librarians used a course wiki that pulled in content from web 2.0 sites like Freemind, Flickr and YouTube to teach information literacy based on the constructivist learning model (Sharpless Smith, Mitchell and Numbers 2007). One librarian at another university decided to use online personality quizzes to teach Boolean logic concepts related to database searching with clearly outlined learner-centered instructional goals (Lowe 2008). At George Washington University, a group of librarians created Muckraker, an online simulation game that enabled students to learn about choosing and researching paper topics; the pedagogy that underlay this effort was evaluated at every stage of the project (Brown, Ceccarini and Eisenhower 2007). These examples have been created by people that realize that offline exercises, instruction techniques and evaluation cannot be transported to the web without being updated, which is a recognition that was rarely realized when tutorials first came online (Tobin and Kesselman 2000, 71; Vander Meer 2000, 242).

How to “sell” interactive web-based information literacy instruction has been the study of Caroline Geck’s research (2006). She calls for librarians to show students how to save time when searching by creating electronic learning modules. She suggests that librarians put an emphasis on time management skills related to Boolean searching (i.e. learning Boolean takes much less time than browsing through a Google search), in order to convince busy students of the usefulness of learning Boolean concepts. Geck also concludes that having an interactive webpage attracts teachers and students to the physical library, particularly those students that have always grown up with Internet technology. While these students may frequent the physical library more because of the website, they still increasingly expect that library resources will come to them by being available over the web and via mobile devices. Having the convenience, the ability to manage one’s own learning, and the opportunity to learn at any time of the day where

there is an Internet connection increases the number of potential tutorial users and should be used as a selling point of web-based resources (Geck 2006).

2. Methodology

The tutorial was developed through the use of personas. Personas are imagined possible users that "act as stand-ins for real users" (Calabria 2004). They are most useful in the planning process to stimulate thinking about people rather than abstract concepts. The following is a list of personas and accompanying issues that each persona raised that were used in the development of the tutorial.

Students with different styles of learning

As mentioned in the literature review section above, active learning is designed to incorporate different learning styles such as visual, auditory, reading/writing-preference and tactile/kinesthetic.

An English as a Second Language (ESL) student

This user has basic English skills so text must be simple, jargon-free, with images to illustrate concepts that are not text-dependent. Self-paced learning would be particularly important for the ESL student.

A visually-impaired student.

Current Web content accessibility guidelines suggest that online pages be broadly perceivable and operable by persons with a wide range of abilities (WC3 2008). The visually-impaired student would need to be able to successfully translate the written text of the tutorial into some other format such as speech or Braille.

A hearing-impaired student.

The hearing-impaired student would need to be able to successfully perceive the information presented through narration.

Culturally diverse students.

Students using the tutorial will come from varying cultural background, and will view information through various internalized cultural codes. The symbols and representations used in the tutorial should be as neutral as possible.

3. Results

Combining the information gleaned from a literature review with our personas, our group produced *Invasion of the And-ors*. Grounded by active learning principles and sound information literacy instructional standards, the tutorial offers university students a more effective route to Boolean search understanding outside of the traditional classroom environment.

3.1 Description of Tutorial

The tutorial is broken into two sections: the instruction and the game, as one intergrated section, and the sandbox. The instructional component takes the form of text, animation and audio, and runs several minutes in length. After the instruction is completed for one unit, users can play the game for that unit.

Many popular Flash games online are shooting games. The game for the tutorial is also a shooting game to take advantage of this popular genre. It is based on the cult-classic "Space Invaders" game. In the game, several alien ships want to attack Earth. Only one of these ships, however, is dangerous and needs to be neutralized. In order to figure out which one of the ships to target, the user has to solve a Boolean search logic question. All of the answers are numbered, and these numbers correlate with the numbers on the alien ships. The user has control over a gun station, which she or he uses to shoot down the numbered alien ship that corresponds with the correct answer to the question. If she or he shoots down the correct ship, the user gains points toward saving the Earth. If the user is incorrect, the aliens drop their explosives onto the Earth's surface.

The sandbox is a place for tutorial users to play around with Boolean concepts without the pressure of timing or scoring. Users select a colour, a Boolean operator and an item from menus. For example, if "blue," "OR," and "triangle" were selected, all of the blue shapes and all of the triangles, regardless of colour, would separate themselves from the items on the sides of the screen and fly into the middle of the sandbox.

3.2 Incorporating Active Learning

Bodie et al. argue that the "best way to teach complex material is to break it into small, manageable units or bits of information" (2006, 121). The tutorial is based on small units of information, with AND and OR Boolean searching taught initially through separate units of learning and game. Once information has been grouped into small units of information, these bits are then assembled into clusters. This clustering improves students' ability to remember what is being taught (Bodie et al. 2006). The two AND and OR units are combined in the third unit of the tutorial and game, in order to unify the individual explanations into a coherent whole.

Levels of engagement are increased when students are given a clearly defined task (Schrand 2008). Thus, in all areas of the tutorial (with the exception of the sandbox), users receive clear instruction and missions. Successful online active learning allows students to participate, act, react and reflect (Nirmalakhandan et al. 2007). The tutorial integrates opportunities for students to undertake all of these actions. The game in particular allows students the chance to act via choice of options, and then reflect on their choices based on whether their answers "saved the Earth" or not. Additionally, research has shown that the most effective active learning exercises contain an element of repetition. Repeating concepts has the impact of reinforced learning and helping students make connections with other material (Bodie et al. 2006; Nirmalakhandan et al. 2007). Repetition occurs by allowing users to explore and modify tasks in the sandbox mode, to replay a level in the game, to repeat a unit of instruction and game, and to increase the difficulty of a level while teaching the same concepts.

The game and tutorial as also short (Chung and Chen 2007) and very interactive (Bromham and Oprandi 2006), which are appealing to students and effective in transferring information. Active learning in an electronic environment is made more effective with strong methods of communication between students and their peers as well as with their instructor. Effectiveness increases when in-person instruction is integrated into learning (Bromham and Oprandi 2006; Eriksen 2004) and when it is situated in a larger learning environment (Hutchings et al. 2007). This suggests that while the tutorial

can stand on its own, ideally it would be used in conjunction with in-person library instruction sessions. Librarians who use the tutorial may want to have students work in pairs during sessions to increase student-to-student communication. The tutorial gives contact information for librarians so that users, especially stand alone users, can receive further help.

3.3 Incorporating Personas

Students with different styles of learning

Many learning styles as possible were accommodated at every step in the tutorial by including visual, auditory, reading/writing and kinesthetic information. The entire learning module is narrated and includes animation, colour, text directions and visual directions. Different sections of the tutorial emphasize learning by self-directed exploration, by formal instruction, and through the game.

An English as a Second Language (ESL) student

The text was simple with many supporting illustrations to convey reinforcing, text-free information. The repetition of the sections as well as the self-paced learning in the sandbox would be particularly important for the ESL student.

A visually-impaired student.

The visually-impaired student would need to be able to successfully translate the written text of the tutorial into some other format such as speech or Braille. The tutorial is purposefully designed to enable a screen reader program to successfully translate the written text into speech. The program was written with Flash in such a way as to make the text accessible. The narrated components to the instruction should be useful to visually-impaired users. The game sections are not readable by screen reader programs, and this is addressed in the "Future Directions" section of this paper.

A hearing-impaired student.

The hearing-impaired student would need to be able to successfully perceive the information presented through narration. The literature on the most effective way of teaching deaf students suggests the use of American Sign Language (ASL) (Roberts and Fel 2006). While it may be possible to implement a picture-in-picture option making ASL translation possible, it was not feasible for this project. ASL also does not help most people who are hard-of-hearing and are not completely hearing-impaired, as members of this group may not understand ASL. Thus, the tutorial uses another frequently cited option in the literature – close captioning. Close captioning is easy to turn on and off, and is useful to both deaf and hard-of-hearing students (Tomlinson 2006).

Culturally diverse students.

Students using the tutorial will come from varying cultural background, and will view information through various internalized cultural codes. The symbols and representations used in the tutorial should be as neutral as possible. For example, animals were initially considered instead of using shapes in the Boolean constructions. However, some animals convey different cultural meanings, both positive and negative. An eagle is sacred to some First Nations groups in British Columbia. A cow is sacred to many Hindu and Zoroastrian people from India. Using neutral shapes in the tutorial and game should maintain interest for all users without causing offensive to some users.

4. Conclusion and Future Directions

This project was based upon the needs of librarians for developing a creative and engaging way of teaching searching techniques to students. A Flash-based game was chosen as the medium to teach Boolean searching due to the interactivity it allows, a principle that was emphasized throughout our literature review as one that helps to develop higher-order thinking skills in students. This relates directly to the concept of Active Learning, going beyond simple memorization to allow students to synthesize concepts and evaluate as they progress. Active Learning principles benefit both the student and the institution through greater student satisfaction and understanding. Studies in information literacy more specifically point to the benefits of the digital environment, coupled with sound pedagogy, in providing a more effective learning experience. Game design and development proceeded with use of the persona method, incorporating the needs of an ESL user, a visually impaired user, a hearing impaired user, and those coming from diverse cultural backgrounds and learning styles. The result is a creative, web-based tutorial that layers emerging knowledge in Flash design onto a new approach to teaching Boolean logic.

With the rise of the evidence-based librarianship movement, it is increasingly important for librarians to base decisions on solid research. Although an assessment piece was outside the scope of this project, it is a vital future step if the tutorial is to be successful. Is the tutorial being used? Who is using it? Is it effective in teaching the concepts of Boolean search logic? Methods of assessment that are most commonly used for the evaluation of web-based tutorials and software include focus groups, think aloud interviews and online surveys. A combination of these methods would be most helpful in evaluating the tutorial. The participants should be a mix of students and experts, as this is the preferred breakdown of participants in tutorial evaluations in the education literature (Chung and Chen 2007). A complete assessment should aim to sample a variety of students, including some of those mentioned in the personas. Once an assessment is completed, the tutorial would be adapted based on the findings and re-evaluated

In addition to assessment, a major future direction for the project would be to add a text-based game for visually-impaired users dependent on text-to-speech programs. While people in this situation can currently access the tutorial, they cannot play the Flash game. Thus, it would be an appropriate and useful addition to add a game that can be played via a text-to-speech program. A text-based game based on building shields over the Earth to protect it from attacking aliens, rather than shooting aliens, would also appeal to users who are philosophically opposed to shooting or who have physical barriers to manipulating the keyboard under the current game mechanics. Another future step relates to the incorporation of Indigenous and Aboriginal ways of learning, perhaps by including a persona with an Aboriginal identity.

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