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The Web-Based Environment: A Participatory Theory-Based Design Process for Development and Evaluation

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Abstract: Web-based environment has become a dominant factor in business, academia and everyday life. As a consequence, internet service providers and application service providers have created a revolutionary new model for driving new applications, hardware and software development. However, many of the developmental approaches lack two important considerations needed for implementing web-based environment; integration of the user interface design with participatory design and development of the evaluation framework to improve the overall quality of web-based environment. This study addressed these two weaknesses while developing based on a user participatory, web-based environment for Online Digital Talking Books production system using streaming media technology (ODTBs). The research goals of the study focused on the improvement of the design process and usability of the web-based environment based on a theory-based Participatory Integrated Design Process (PIDP). Results indicated that the proposed PIDP was effective in that the study showed the main goal of project had been achieved. The PIDP provides excellent potential for develop and evaluation. The process is easy, effective access to information and also implies an integrated performance of development method. The study also confirmed that for a web-based environment to be successful, various aspects of the online environment should be considered such as application domain knowledge, conceptual theory, user interface design and evaluation about the overall quality of the design environment.

Key words: Human-computer interaction, usability evaluation, online system, PIDP, ODTBs, Thailand

INTRODUCTION

As an increasingly powerful, interactive and dynamic medium for delivering information, the world wide web (web) in combination with information technology has found many applications. However, many approaches still lack two important considerations needed for implementing applications based on the web; integration of the user interface design with participatory design and development of the evaluation framework to improve the overall quality of web-based environment.

Access to information and knowledge is very important for people. However, there are restrictions on access for certain groups of people. Print disabled (that is the blind, partially sighted, dyslexics and some of those with visual impairments), physically handicapped, learning-disabled find difficulty in accessing information even though, they have human rights to access education, facilities and technology. Print disabled persons should have similar opportunities to others. Contextually, the majorities of disabled persons are ignored and cannot access the technology and facilities. Many studies have demonstrated the advantages of using information and communication technology for disabled people. These benefits include the enhancement of their daily functions and literacy, extension of social networks, improvement in independence and quality of life and the facilitation of empowerment (Davies *et al*., 2002). In recent years, technology has rapidly become more advanced and affordable. It has been used commonly as therapeutic or training media for disabled people (Aspinall and Hegarty, 2001). However, the useful assistive technologies can practically help handicapped people to access groups of information. In the case of the blind, the technology for converting text to speech is very helpful. Unfortunately, information has been stored in a different languages, formats and locations. Most of it is available on the internet but a good deal of useful knowledge has been commercially stored in paper-based book form and is not easily accessible for the blind. There is a published standard for formatting paper-based books to the Digital Talking Book format (DTB), commonly called DAISY or Digital Accessible Information System (Information Technology Accommodation Division. For many years, DAISY has been made available to print-disabled readers on analog media such as phonograph records and audio cassettes. These media serve their users well in providing human speech recordings of a

wide array of print material in increasingly robust and cost-effective formats. The DAISY allows the user to easily skip over or read footnotes and also offers the print-disabled user a significantly enhanced reading experience that is much closer to that of the sighted reader using a print book.

The additional goal of DAISY books is to develop and provide a system which is easily integrated into DTB production and which is able to make use of future technologies to provide equal or better, access to the information in a book than is available to a fully able reader of a paper-based book.

Researchers first give an overview of relevant literature that guided the design, development and evaluation of the web-based environment supporting Digital Talking Books production system using streaming media technology (ODTBs). The development process will then be briefly summarized. In addition, evaluation processes through the proposed formative evaluation framework will be outlined. Finally, relationships between the design process framework and the effectiveness of the web-based environment will be studied.

Literature review

Review of internet technology: Now-a-days, internet technology has become a dominant factor in business, academia and everyday life. As a consequence, internet service providers and application service providers have created a revolutionary new model for driving new applications, hardware and software development. The strong advantage of internet is not only delivering the hard bound texts but also include multimedia elements such as sound, video and interactive hypermedia (McNeil *et al*., 2000).

Now-a-days, the internet is a public, cooperative and self-sustaining facility accessible to hundreds of million of people worldwide. Physically, the internet uses a portion of the total resources of the currently existing public telecommunication networks. Curriculum, administration and assessment are all affected as members of the educational community experience changes in communication and commerce that are a result of the explosive expansion of the internet (Austin and Mahlman, 2000).

The internet technology known as the world wide web is rapidly emerging as the most powerful medium of mass communication this century and it can be harnessed to dispense global, cost-effective, high-quality, multimedia communication education material. Internet technology can provide flexibility and convenience. It can overcome some traditional barriers such as time and place. A user can access materials independently online (Ryan, 2001). Moreover, the use of internet as the communication platform can help information transfer more effectively during the construction process. Besides its speedy transmission, it also saves cost in communication with overseas construction sites through the computer network compared to the traditional information handling methods.

Review of user interface design for web-based environments: For a web-based environment to be successful, it is also important to effectively facilitate learner interactions with the learning environment. An effective user interface in web-based environments is important because it determines how easily user can focus on it without having to make an effort to figure out how to access them (Lohr, 2000). There are a number of design approaches to the user interface each of which has its own strengths and weaknesses.

In order to design user interfaces that are easy to use and intuitive to anyone, it is important to have good design skills as well as some knowledge of psychology, methodologies and prototyping. Therefore, all four approaches are fundamental to successful design of web-based environments. However, designing a usable interface that is also user-centered is not trivial. Thus, this study suggests employing a participatory user-centered design process that takes human factors into account. Gould and Lewis (1985) provide three principles of user-centered design; an early focus on users and tasks; empirical measurement of product usage and iterative design whereby a product is designed, modified and tested repeatedly.

Rubin (1994) also suggests several techniques, methods and practices that can be used for the user-centered design. Some of the examples include participatory design, focus group research, surveys, design walkthroughs, expert evaluations and usability testing.

Review of digital talking books: The DTB like analog talking books, renders audio in human or synthetic voice (Christensen and Duhring, 2006). Additionally, the DTB can contain image files and a forthcoming version will also include a video playback capability that offers a wide range of features in order to provide services to a broader audience including deaf and hearing impaired people. The audio file must be either in MP3, WAVE, MPEG-1 or MPEG-2 layer III or MPEG-4 AAC format. The text of a book is marked up in Extensible Mark-up Language (XML), a World Wide Web Consortium (W3C) standard somewhat reminiscent of HTML, the language used for web pages. For use in digital talking books, the

XML mark-up must adhere to a specific Document Type Definition (DTD) defining the legal building blocks of the XML file. The DTD for a DTB is publicly available through the DAISY web pages. The synchronization is mediated by Synchronized Multimedia Integration Language (SMIL) files which ensure the parallel presentation of the text part and the audio part of a DTB.

The SMIL files for DTBs follow a DTD of their own. SMIL is a W3C standard. The Navigation Control Center (NCC) consists of a Navigation Control file for XML applications (NCX) file which is an XML application structured in accordance to a separate DTD. The NCX contains navigation points for both text and audio and can be likened to a table of contents.

Each navigation point in the NCX is linked through a SMIL file to the corresponding location in the audio and XML textual content files, providing direct access to that location. The NCX controls the global navigation and provides access primarily to relatively large parts of the document.

The NCX provides an overview of all the points in a text to which a user may navigate and offers direct access to selected structures in the book such as page numbers, notes and figures. Once an NCX item has been selected, local navigation such as movement within a list or table or among a group of words, sentences or paragraphs it becomes possible. DTBs are not required to contain all of the possible constituents mentioned before (Nes and Stenberg, 2007).

MATERIALS AND METHODS

System design: Systems can be successfully designed by considering the various aspects of the web-based environment such as technology, knowledge, conceptual theory, standard, human-computer interface design and system evaluation. A few frameworks are available for the development of web-based environments that support DTB production. However, these factors are rarely taken into account in the design process. The purpose of this study was to develop the design process by using a Participatory Integrated Design Process (PIDP) as shown in Fig. 1.

Participatory Integrated Design Process (PIDP): The participatory integrated design process is a framework for web-based development. As show in Fig. 1, the process consists of four phases of design each of which has its own protocol. These phases are needs analysis, conceptual design, development and evaluation. The researchers used the PIDP framework to encompass the

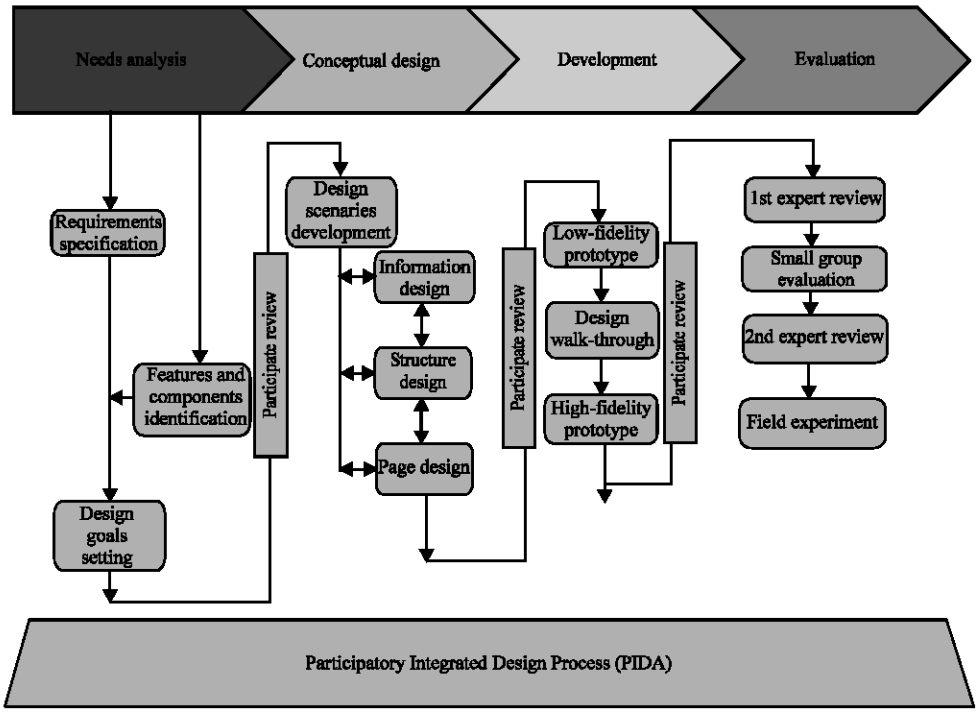

Fig. 1: Participatory Integrated Design Process (PIDP)

entire process of development starting from the early needs analysis phase and continuing through to the evaluation phase. The PIDP was adapted by adopting another of the Integrated Design Process (IDP) (Chang and Tonya, 2007) and six User-centered Designs (UCD). The IDP considers two main systems, the learning environment and user interface system which covers from the early needs analysis phase to the evaluation phase. In case of the UCD principles, it offers several critical advantages by enabling them to develop ease-of-use products, satisfy customers, decrease expenditure on technical support and training, advertise ease-of-use successes and ultimately increase market shares. However, IDP and UCD principles are not widely practiced even if they have efficiency benefits. For this reason, the researchers revised the UCD and IDP systems and developed them to the design process for web-based environments. The PIDP comprised four phases as follows:

Phase 1: Needs analysis: This phase was concerned with gathering information about situations, problems and needs and analyzing and summarizing information that was necessary to build the prototype. It consisted of three design processes, namely requirements specification, features and components identification and the setting of design goals. The requirements specification was aimed to specify the user and system related requirements while developing a full understanding of the target user group and its tasks. The process of setting design goals describes the design goals and principles that drive all design decisions throughout the development and also serve as a rechecking mechanism for collective testing in the participatory review phase.

Phase 2: Conceptual design: This phase focused on an explicit construction of concepts involved with; what the components is; what it can do and how it is intended to be used. It consisted of four design processes. These were design scenarios development, information design, structure design and page design. In this phase, all the processes can be aligned to the user's requirements in a term of a conceptual user interface and production. The output data of conceptual design can be used as an outline of the user interface and production system prototype. It was used for rechecking in collective testing in the participatory review phase before it was input to the development phase.

Phase 3: Development: This phase aimed at constructing a high-fidelity prototype of the digital talking book production system, based on the results of an initial user evaluation of low-fidelity ones. It consisted of three design processes, namely the low-fidelity prototype, design walk-through and the high-fidelity prototype. The low-fidelity prototype process described the methodology to build a rough interface and system by integrating design ideas that were developed in the previous ones. The step of design walk-through was concerned with soliciting initial feedback from users. Its goals aimed at confirming the proposed design and revising the low-fidelity prototype before full functionality was implemented. In the final process, the high-fidelity prototype described the complete development of full functionality. The main objective of this phase was to translate the conceptual user interface and structural design into a high-fidelity prototype that perfectly demonstrated the goals of this research. Furthermore, the output of the high-fidelity prototype was evaluated by a group of participants in the review phase.

Phase 4: Evaluation process: The evaluation phase was primarily focused on the identification of current weaknesses in the entire system prototype that could be revised by using a systematic design of evaluation approach. Evaluation consisted of a 1st expert review, a small group evaluation, a 2nd expert review and field experiment (Dick and Carey, 1996).

Online Digital Talking Books production system using streaming media technology (ODTBs): The ODTBs is started at http://innomedialab.com (Fig. 2). The mainly module of audio streaming for DTB production display typical content and sound record system then user can read by following the content and record for DTB. User interface of this module is divided into various sections frames. At the down sides of the user interface show that the audio control window then user can produce DTB by read content on the right hand side. After that audio's reader was showed recorded and uploaded to audio streaming server. At the top of the user interface, we put the basic buttons of using the system as shown in Fig. 2. For the audio streaming researcher took into account certain criteria for the quality of audio, like flv audio format and the high quality of audio. Finally, research present the DTB production tools of the system where all the included features can be seen. The system provides the following features that are properly adapted to the users' special requirements:

- Content extraction: tool of content extraction for further search
- Search: tool of content retrieval according to search keywords
- News: tool of announce new information to member
- Web board: tool of pose questions or communication with member group
- Download: tool of delivery more material and electronic content to group of member

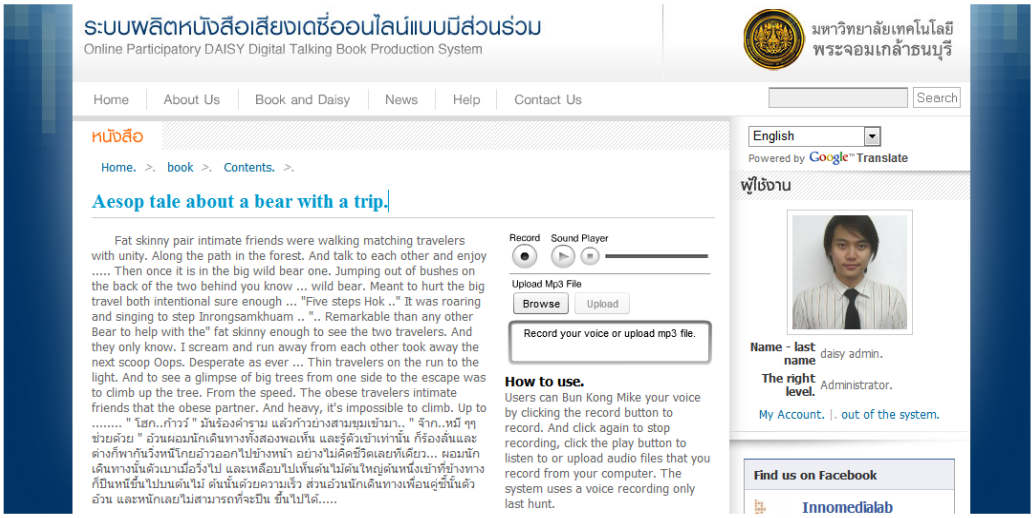

Fig. 2: Main webpages of ODTBs

- Member: tool of register new user and tracker of the statistics of the member activities
- Site map: a map of the site links and structure

RESULTS AND DISCUSSION

This study used the four stages of evaluation created by Dick and Carey (1996) consists of; 1st expert review, small group evaluation, 2nd expert review and field experiment.

The evaluation criteria for determining the overall quality of the software testing, its clarity and impact were defined by ISO 9241-110 (2006) (International Organization for Standardization) and the satisfaction of the system was determined according to usability criteria, effectiveness, efficiency and satisfaction and followed ISO 9241-11 (1998) (International Organization for Standardization). The surveys used a 5 point Likert-type scale (1 = strongly disagree, 5 = strongly agree).

The 1st expert review phase: Eleven experts with a high level of expertise in this research field reviewed the prototype version of ODTBs to identify any deficiencies or problems and provided recommendations for its improvement. The evaluation criteria determined the overall quality of the software testing, its clarity and impact and the experts' estimation provided a recommended design for the modification of the system. The overall quality of the system design was good and the degree of clarity of the system was rated higher than target levels. The suitability of the concepts, the suitability for the task, suitability for learning, suitability for individualization, conformity with user expectations, the self-descriptiveness, controllability and error tolerance were shown to have means of 4.40 (SD = 0.37), 4.00 (SD = 0.40), 4.10 (SD = 0.57), 4.00 (SD = 0.49), 4.30 (SD = 0.28), 4.01 (SD = 0.42), 4.20 (SD = 0.48) and 4.10 (SD = 0.38), respectively (Table 1). According to the experts' suggestions, several designs were changed including a redesign of graphic figures and more options for editing messages (such as font color and size).

Table 1: Means and standard deviations for ODTBs prototype by expert review (1st)

Categories	M	SD
Concepts	4.40	0.37
Suitability for the task	4.00	0.40
Suitability for learning	4.10	0.57
Suitability for individualization	4.00	0.49
Conformity with user expectations	4.30	0.28
Self-descriptiveness	4.01	0.42
Controllability	4.20	0.48
Error tolerance	4.10	0.38

The small group evaluation phase: In this process, representative users identified and removed more prominent errors from the ODTBs prototype. Eleven users, focused on the suitability of the system for users. The level of satisfaction was determined through four categories of usability criteria, namely effectiveness, efficiency and satisfaction. These showed means of 0.28 (SD = 0.46), 4.25 (SD = 0.45), 4.39 (SD = 0.50) and 4.40 (SD = 0.51), respectively (Table 2). Moreover, this phase also summarized and changed the main design in order to solve the usability problems that had been identified in the quality of the audio recording module and the user interface.

The 2nd expert review phase: In this process, the ODTBs prototype was finally reviewed again by eleven experts

Table 2: Means and standard deviations for ODTBs prototype by the small group evaluation

Categories	M	SD
Usability criteria	4.28	0.46
Effectiveness	4.25	0.45
Efficiency	4.39	0.50
Satisfaction	4.40	0.51

Table 3: Means and standard deviations for ODTBs prototype by expert review (2nd)

Categories	M	SD
Concepts	4.60	0.47
Suitability for the task	4.49	0.40
Suitability for learning	4.40	0.37
Suitability for individualization	4.35	0.39
Conformity with user expectations	4.59	0.30
Self-descriptiveness	4.29	0.38
Controllability	4.50	0.32
Error tolerance	4.60	0.28

Table 4: Means and standard deviations for ODTBs prototype by the field experiment

Categories	M	SD
Usability criteria	4.30	0.36
Effectiveness	4.35	0.34
Efficiency	4.42	0.45
Satisfaction	4.49	0.47

who exhibited a high level of expertise in these fields of interest. Their task was to identify any deficiencies or problems and provide recommendations for the improvement of the prototype. The evaluation criteria was determined in eight areas, namely suitability for the concepts, suitability for the task, suitability for learning, suitability for individualization, conformity with user expectations, self-descriptiveness, controllability and error tolerance. These had means of 4.60 (SD = 0.47), 4.49 (SD = 0.40), 4.40 (SD = 0.37), 4.35 (SD = 0.39), 4.59 (SD = 0.30), 4.29 (SD = 0.38), 4.50 (SD = 0.32) and 4.60 (SD = 0.28), respectively (Table 3). The overall quality of the system design was good.

Field experiment phase: This process was carried out by thirty volunteers that had produced a digital talking book and thirty print disabled users. The study group assessed the effectiveness of ODTBs. The field experiment was also conducted to identify a way of evaluating the quality of users. The level of satisfaction was determined through four categories, namely usability criteria, effectiveness, efficiency and satisfaction. These showed means of 4.30 (SD = 0.36), 4.35 (SD = 0.34), 4.42 (SD = 0.45) and 4.49 (SD = 0.47), respectively (Table 4). The overall quality of the system design was estimated as good and the degree of clarity of system was rated higher than target levels.

CONCLUSION

In this study, the researchers have offered a framework and design process for the web-based environment. The implementation of PIDP involved several steps including a consideration of various aspects of information, conceptual development, human-computer interface design and evaluation of the overall quality of the system environment. In particular, the research aims to improvement of the design process and usability of the web-based environment.

Finally, this study evaluated the concept of Participatory Integrated Design Process (PIDP) and using for develop Online Digital Talking Books production system using streaming media technology (ODTBs). It was confirmed that the PIDP provides excellent potential for development and evaluation. The process is easy, effective access to information and also implies an integrated performance of development method. The study also confirmed that for a web-based environment to be successful, various aspects of the online environment should be considered such as application domain knowledge, conceptual theory, user interface design and evaluation about the overall quality of the design process.

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REFERENCES

Aspinall, A. and J.R. Hegarty, 2001. ICT for adults with learning disabilities: An organisation-wide audit. Br. J. Educ. Technol., 32: 365-372.

Austin, J.T. and R.A. Mahlman, 2000. Using the Internet for career-technical assessment: A pilot project in Ohio. J. Career Tech. Educ., 16: 27-39.

Chang, S. and L. Tonya, 2007. Web-based learning environment: A theory-based design process for development and evaluation. J. Inform. Technol. Educ., 6: 23-43.

Christensen, T.K. and M. Duhring, 2006. Access to information on demand by the aid of digital talking books. Intell. Paradigms Assistive Prev. Health Care, 19: 117-132.

Davies, D.K., S.E. Stock and M.L. Wehmeyer, 2002. Enhancing independent time-management skills of individualswith mental retardation using a palmtop personal computer. Ment. Retard., 40: 358-365.

Dick, W. and L. Carey, 1996. The systematic design of instruction. Harper Collins, New York.

Gould, J.D. and C. Lewis, 1985. Designing for usability: Henry ledgard editor key principles and what designers think. Commun. ACM, 28: 300-311.

ISO 9241-11, 1998. Ergonomic requirements for office work with visual display terminals (VDTs)-part 11: Guidance on usability. International Organization for Standardization. http://www.iso. org/iso/ iso_ catalogue/catalogue_tc/catalogue_detail.htm?csnumber=16883.

ISO 9241-110, 2006. Ergonomics of human-system interaction-part 110: Dialogue principles. International Organization for Standardization. http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=38009.

Lohr, L.L., 2000. Designing the instructional interface. Comput. Hum. Behav., 16: 161-182.

McNeil, S.G., B.R. Robin and R.M. Miller, 2000. Facilitating interaction, communication and collaboration in online courses. Comput. Geosci., 26: 699-708.

Nes, M. and E. Stenberg, 2007. Appraising and evaluating the use of DAISY. For Print Disabled Students in Norwegian Primary and Secondary Education, Norway. University of Oslo. http://www. duo. uio. no/sok/work.html?WORKID=57590.

Rubin, J., 1994. Handbook of Usability Testing: How to Plan, Design and Conduct Effective Tests. John Wiley and Sons, New York.

Ryan, S., 2001. Is online learning right for you. Am. Agent Broker, 73: 54-58.