Student Evaluation of the Learning Management System Fronter From an HCI Perspective

Frode Eika Sandnes[1], Hua-Li Jian[2], Simen Hagen[3], Olav Talberg[4]

***Abstract* - During the autumn semester of 2006, 104 computer science students at Oslo University College evaluated the learning management system Fronter as part of a human computer interaction (HCI) course. Usability evaluation of information systems is central to the HCI curriculum. This paper summarizes the most important findings in this study. The local administrators of the learning management system were informed of the problems identified and several modifications have since been implemented as a result of the student feedback. Experiences show that usability evaluation of e-learning software is frequently neglected, and that students should be included as evaluators of such e-learning software.**

Key Words- E-Learning, Human Computer Interaction, Learning Management System, Usability evaluation

INTRODUCTION

Fronter is the most widely used learning management system in Norway, followed by its-learning. Only a few institutions use the platforms Blackboard and WebCT.

Fronter is intended as a tool for student-teacher and student-student communication. It comprises about 80 modules. Only a fraction of these modules are employed at Oslo University College. Modules employed include assignment submission, portfolios, e-mail, discussion groups and electronic notice boards. More advanced features such as the calendar is not consistently deployed.

Fronter has received a mixed reaction from staff and students at Oslo University College. At the faculty of engineering, Fronter is mainly used in non-computer related subjects such as civil engineering, applied chemistry, mechanical engineering, etc. The computer science instructors have been more hesitant. Critics fear that Fronter is a beta-product and they do not wish to be dependent on an unreliable and incomplete system. Most of the computer science instructors have been using the Internet for many years already and has developed routines for dealing with student assignments. Some stick to traditional physical media such as paper and floppy disk, while others use e-mail. Some of the computer science instructors have even developed their own web-based assignment submission systems.

During the autumn semester of 2006 the first author asked a class to indicate whether they wanted Fronter to be used in the course. A majority of the students responded that they did not wish to use Fronter. The class discussion revealed that the students preferred to submit assignments using e-mail and a continuously updated course website rather than Fronter. The preference for e-mail is also echoed in the literature [1]. Many of the students had strong opinions about Fronter. This in-class discussion motivated this study.

The first author was teaching the course Human Computer Interaction (HCI) during the same semester. This course addresses the processes involved when humans are using computers and characteristics of effective user interfaces. An important part of HCI is the evaluation of user interfaces [2, 3]. In addition to developing computer systems, the students need the skill to evaluate the effectiveness and value of their projects from a user standpoint. Fronter was therefore used as a case. Both students and teachers are exposed to Fronter. Fronter version 62 is evaluated in this study. The students were informed in advance and gave their consent for the results to be used in this report. Note that several Fronter evaluations exist [4-6]. However, none of these studies address Fronter from a usability perspective. The use of Fronter at Oslo University college is also addressed in [7-10].

EVALUATION METHODOLOGIES

Most studies on e-learning focus on the technical parts of the systems. Exceptions include [4-6, 11]. Most studies on e-leaning system describe some novel e-learning component. However, these studies are rarely assessed in terms of learning effectiveness and user satisfaction [12-16]. A handful of studies document studies based on simple questionnaires with Likert-type questions [14, 15, 17-21]. What these studies have in common is that they are published in two of the most prestigious education journals in their genre, namely Computers and Education on Elsevier, and IEEE Transactions on Education. It is a well known fact that it is very hard to obtain useful information through questionnaires. Questions such as “How well did you enjoy the software?” and “How well did it help you learn?” are unlikely to reveal useful and new knowledge. Such evaluations are particularly useless if the purpose of the evaluation is to improve the system. Some of the studies, such as [14, 22, 23], contain system screenshots which reveal fundamental flaws and deviations from well established user interface design guidelines.

Qualitative studies, such as [24, 25], generally provides more concrete feedback than quantitative studies. Student

[1] Faculty of Engineering, Oslo University College, P.O. Box 4 St. Olavs Plass, N-0130 Oslo, Norway
[2] Department of Languages and Literature, National Cheng Kung University, Univeristy Road 1, Tainan, Taiwan
[3] Faculty of Engineering, Oslo University College, P.O. Box 4 St. Olavs Plass, N-0130 Oslo, Norway
[4] Faculty of Engineering, Oslo University College, P.O. Box 4 St. Olavs Plass, N-0130 Oslo, Norway

comments are easier to interpret and contain more information which may be used to conduct the necessary improvements.

Few studies have evaluated e-learning technology from a more scientific angle. Calcaterra et al. [26] demonstrated that student computer skills are more influential on hypermedia learning processes than cognitive skills. Alexander [27] showed that virtual collaboration is more effective among more senior students than junior students. Vikere, Kitsantas and Chow [28] revealed that students with access to computing resources in their learning environment are more likely to seek help and assistance than students that only have access to tradition non-computing based learning resources. Cleaver and Elbasyouni [29] presented evidence that students tend to repeat online tests until they achieve the desired test score. Furthermore, Grabe [30] observed that students with access to online lectures notes perform better in exams than students without access to online lecture notes. Two independent studies showed that PowerPoint use affects the students perception of the teacher and their interest in the course, but not measurable effect on their learning [31, 32]. Day and Foley [33] obtained evidence that web-based video lectures results in better exam results than traditional lectures.

Few studies have addressed the effect the user interface has on the learning in an e-learning platform. Chen [34] compared three techniques for navigating course websites.

FIGURE 1
CONFIGURING FRONTER

FIGURE 2
ACCESSING FRONTER

LOCALIZED ADAPTATIONS OF FRONTER

Fronter has evolved into a large, flexible and relatively complex system. It is highly configurable and institutions are left to adapt Fronter to suit their pedagogical needs. One should therefore be careful in passing general judgments about Fronter purely based on observations made at one site. At Oslo University College a majority of the configuration is done centrally and the adaptations are common to all the faculties. However, some local adaptations are also done at the faculty level. None of the appointed Fronter administrators at Oslo University College has a degree in computing, nor can document formal competence in human computer interaction.

Users also have the option of configuring aspects of Fronter. Fig. 1 shows an example of configuration abuse.

FRONTER COMPETITORS

Students criticized the size and the complexity of Fronter, and that Fronter provides more functionality than what is actually needed. In many cases widely available competing technologies serve the purpose better. Examples include:

The memory stick provides more storage capacity (gigabytes) compared to Fronter (megabytes). Files on a memory stick are available even when the student is without an Internet connection, such as certain student dormitories, or if the system is down. Most students nowadays possess mp3-players and cell-phones which can store coursework.

Most students criticized the e-mail module built into Fronter. The rationale behind this module is that the user has everything available in one place. However, the user experience in this module does not match the user experience provided by common systems such as gmail and hotmail. Expectations are high. The students indicated that they did not mind logging into a 3rd party system to access mail to get the expected quality. Furthermore, the chat facility in Fronter does not match more mature applications such as MSM.

Students found the Fronter coursework submission mechanism overly complicated. Comparatively, paper-based submission is a cognitively simple process. Assignment submission is discussed in subsequent sections.

ACCESSING FRONTER

The local administrators have added a shortcut to Fronter via the main homepage of the university (see Fig. 2) to simplify access. Principally, a shortcut to Fronter from the university home page is a good idea. It is supported by the HCI-literature which promotes the concept of memory versus recall, i.e., that it is easier to recall something than to remember it (URL). However, the shortcut provided is simply just a small icon depicting the letter *F* that symbolizes Fronter. This mnemonic is problematic. *F* means different things to different people, for instance Frode's homepage or information to students who have been given an F (fail) grade. Furthermore, Fronter was formerly called ClassFronter (CF), and many students and teachers are still using this term. The connection from *F* to ClassFronter is less obvious. A better solution is simply "Fronter".

FIRST IMPRESSIONS

Users are overloaded with information when logging into Fronter for the first time. Students may loose focus of what they goal. Some information could be omitted such as old and read news and e-mail messages. The notice board is perhaps the most important component on the welcome page. However, this component is hidden at the bottom of the page. If the student uses a screen with a low resolution, or the page is filled with information, the notice board will not be visible unless the user scrolls down.

Fronter can be configured to show a fixed number of messages, but few students do. The news employs a "read more" link. The literature on HCI recommends that instead of such links one turns the title into a hyperlink (news site pattern). Students also requested the ability to maximize each sub window on the welcome page, in addition to a search function. Some students prefer search as a primary means of navigation.

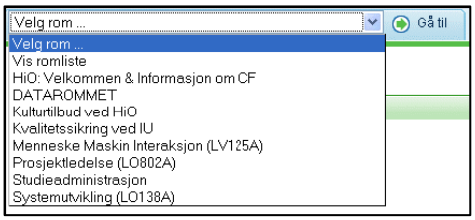

FIGURE 3
FRONTER NAVIGATION

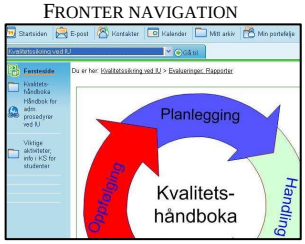

FIGURE 4
VISUAL INCONSISTENCY

FIGURE 5
TOO MANY HYPERLINK STYLES

NAVIGATION AND VISUAL AFFORDANCES

A pull-down menu is used as the primary navigational aid in Fronter as used at the faculty of engineering (see Fig. 3). This poll-down menu is probably the most noticeable shortcoming of the system. The system uses a notion of "rooms", and users choose their target rooms from this menu. Only rooms accessible by a particular user are shown.

Pull-down menus provide limited visual affordance. Not everybody knows that the list has to be clicked in order reveal the list of choices. All the choices remain hidden until they are uncovered by the user. An important HCI principle is to make all the crucial opportunities visible to the user.

A common trend is to employ either a sidebar menu or a top menu with one or more levels. In fact, such menus are used in other parts of Fronter. Another effective tool is a tabs. Tabs are used in some Fronter modules including the e-mail module.

Moreover, the entries in the poll-down menu are arranged alphabetically. However, practice shows that navigational information is best organized according to subject. This organization is also consistent with the gestalt principles of proximity and distance. Related entries are grouped together, and unrelated entries are spread further apart. It is difficult to design good lists for navigation. A popular technique called card sorting can be used where one collects the opinions from a panel of users and the results are combined using statistical clustering techniques. The entries are grouped such that they are meaningful to a majority of users.

The choice of vocabulary is important. In the local adaptation of Fronter the entry "COMPUTER ROOM" is not self explanatory. However, the upper case letters signals the importance. Generally, it is easier to read lower case letters than uppercase letters. Uppercase can be used to achieve the effect of contrast and emphasis. This effect was probably not intentional.

Fronter provides relatively good orientation, i.e., that the students at any time know where they are in the system. The two most common techniques used are breadcrumbs and menu highlights.

The pull-down menu and other menus should only provide relevant alternatives to the student. The list should for instance only contain links to courses being taken by the students. If students withdraw from a course prematurely or successfully completes a course the course should no longer be provided as an alternative.

VISUAL PROFILE AND CONSISTENCY

Fronter allows the teachers' own material to be integrated which is likely to result in visual inconsistencies (see Fig. 4). Fronter is realized with one visual style and the teacher is likely to have used a totally different style. Two or more different styles result in inconsistencies. This inconsistency is not a major issue but it does, however, give the user the impression of chaos and lack of professionalism.

Fig. 5 shows that the developers of Fronter have been sloppy regarding hyperlinks. One student identified as much as seven different hyperlink styles. A good hyperlink is characterized by the fact that the user immediately knows to click on the link. It is a convention that hyperlinks should be underlined and preferably be colored blue. Fig. 5 shows three underlined hyperlinks. One is blue, one is black and one is grey. The remaining four hyperlinks are not underlined. The developers should have reduced the number of hyperlink styles to perhaps two or three. Fewer colors would give the user interface a stronger sense of consistency and uniform style.

One major problem is that each room, or space, is different. Each course instructor is responsible for configuring the vertical left menu and the folder structure for each course. A better option would probably be a standardized menu and folder structures. A standardized structure would allow students to more easily orient themselves and reuse their knowledge from one course to another without retraining.

Fronter supports multiple locales, including Norwegian, New Norwegian, Sami and English. The internationalization capabilities in Fronter match the increasing internationalization at the campus and the multicultural profile of the university. However, courses are not taught in Sami at Oslo University College.

Inconsistencies exist in the translations. The Norwegian version of Fronter includes English words such as *template* and the English version is filled with words in Norwegian such as *startsiden* and *mitt arkiv*. Such inconsistencies can be problematic for visiting exchange students that do not speak Norwegian.

The teacher may redefine the labels of various elements. However, these changes are limited to a single locale. For example, elements that are given a custom Norwegian label will be shown in Norwegian regardless of the students' locale.

COLORS

The default version of Fronter employs a combination of green and blue (analogous colors). Red and orange is also used (complementary colors). Yellow is also used. Yellow, red and blue comprise a triadic color scheme. The students found it difficult to categorize these overlapping color schemes. The users would probably perceive Fronter as more consistent if fewer colors were used.

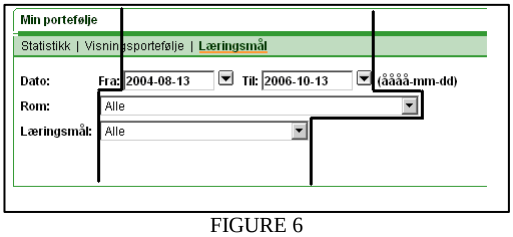

FIGURE 6
BROKEN INVISIBLE LINES

ALIGNMENT AND HIDDEN LINES

HCI borrows extensively from the Gestalt psychology and especially the principle of continuity is frequently sited. Alignment of elements along invisible lines makes the interface appear tidy and more professional.

Fronter demonstrates many examples of good use of gestalt. Fig. 6 shows examples where the gestalt principle of continuity is not adhered to in the form of broken invisible lines. The four elements are not aligned vertically and the two pull-down menus have different lengths. The date fields should also be aligned with the other elements. Furthermore, the date fields require the user to use the right format. This field is a possible source of error and it would perhaps be better if the calendar metaphor, such as the ones commonly used for online flight booking, was used instead. Moreover, the current year should be used as a default value.

FIGURE 7
BROKEN INVISIBLE LINES

Another problem is that the university logo is included in the Fronter layout. Fig. 7 shows that the logo is too large and clumsy. In addition, it breaks the invisible lines in the interface. An immediate fix would be to reduce the size of the logo. A more permanent solution would be to employ a professional graphic designer to integrate the university logo into the overall visual profile.

METAPHORS AND CONVENTIONS

A metaphor can be a useful tool for helping a user to quickly grasp the concept of the user interface and to build up a working mental model of how the interface works, with little or no training. On the other hand, metaphors must be used with care as they can easily work against their intention.

The documentation states that Fronter is based around five metaphors: building, room, key, tool and participant. Most of the students objected to how metaphors were used in Fronter. The key-metaphor competes with the established password metaphor. Users are already familiar with passwords and usernames and the concept of a key is more confusing than helpful. The developers of Fronter should stick to established conventions and widely accepted metaphors that users recognize.

The room metaphor is also problematic. Students generally agreed that the folder metaphor is more common and easier to understand.

The building and tool metaphors are less obvious. Fronter is making effective use of the calendar metaphor, folder metaphor and e-mail metaphor in various parts of the system.

ICONS – RECOGNITION OR EYE-CANDY

Icons are widely used in Fronter. The HCI literature suggests that icons are used together with text as a visual alternative to reading the text. Reading is a cognitively more challenging operation and a well designed icon can be recognized much faster than it takes to read a word.

FIGURE 8
CALENDAR ICON A

FIGURE 9
CALENDAR ICON B

Fig. 8 depicts an icon symbolizing a calendar. Fig. 9 also shows a calendar icon. Both icons are present in the horizontal top menu in Fronter, which is always visible. What are the differences between these calendars? The icon in Fig. 8 is an actual calendar, while the icon in Fig. 9 represents the starting point. Several students suggested replacing the current start icon with a picture of a house. Many users are familiar with the house icon in browsers, where it usually symbolizes the start-page.

FIGURE 10
CALENDAR ICON A

Fig. 10 is a very good example for poor icons in Fronter. This example shows two different alternatives with the same icon. In this instance the icon has no informational purpose.

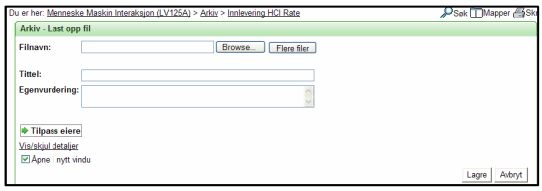

FIGURE 11
ASSIGNMENT SUBMISSION DIALOG

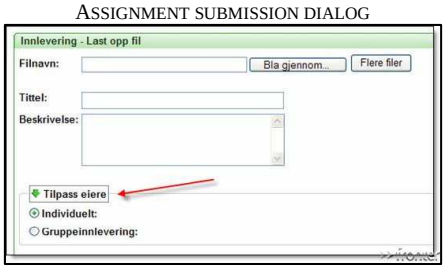

FIGURE 12
SPECIFYING INDIVIDUAL OR GROUP WORK

ASSIGNMENT SUBMISSION

The ability to submit assignments were indicated as the most important functionality from the students' point of view, and most students were unhappy with this facility in Fronter.

First, it is difficult to locate the function. Multiple clicks are needed to reach the correct course specific folder. The upload link is small and is positioned anonymously at the top leftmost part of the screen. Such important functions should have greater visibility. Second, the upload function is difficult to use (see Figs. 11-12). Fig. 11 shows the dialogue for file upload. The user will recognize the file upload control from its visual appearance as it looks much like the attachment upload controls found in web-based e-mail systems. In addition, the forms comprise a title field and self-evaluation field. These less important fields occupy much screen real estate and visual attention. The title of the file and the context of the submission should suffice.

Java components for uploading or downloading multiple files are provided. Not only are the users required to have java correctly configured for the browser, but also introduces a different interface style. It requires users to accept a security warning, granting the java applet access to the local disc, which, in a virus-infested world, might be frightening for many users.

At the bottom of the form a link is provided that expands a new menu. Here students indicate whether the work is an individual endeavor work or teamwork – an important detail from a student's perspective as teamwork is commonplace at the faculty of engineering. The mane of the link, "Customize owners", only partly hints at the functionality hidden underneath. A student that is close to a deadline may panic and not be able to find this choice as it is hidden. The developers should have made this option more visible.

A positive aspect of the submission system in Fronter is that the students are given a clear receipt when their assignment is successfully uploaded. E-mail based submissions suffer from a lack of feedback. Did the teacher receive the e-mail? The e-mail address may be incorrect, the message might have been filtered by as spam or denied by a schools e-mail system if the attachment is too large, the teacher might have lost the assignment, it may have disappeared among the large quantity of other e-mails or the teacher might have deleted the message accidentally.

The students also praised the fact that it is possible to set a hard deadline. This mechanism is fairer than the one provided by e-mails, as it is hard to determine if a late e-mail is composed late or its delivery delayed.

One problem however, is that students can upload multiple versions, and the teacher then has to choose version. Which one is correct? It would perhaps be better if a new upload would overwrite the previous version to eliminate ambiguities.

With group hand-ins, it is also possible that several students hand in the work on behalf of the rest of the group. Teacher therefore may have to choose from several versions. In the best case, the versions are identical, but they are often not in practice.

TECHNICAL LIMITATIONS

The students reported that storage limitations existed for uploaded files. A university specific limit of 2 Mb was observed. Clearly, 2 Mb is insufficient for files containing graphics authored with modern office tools such as Microsoft Word or PowerPoint. Note that the local Fronter administrator disputes these storage limitations.

A problem with Fronter is its use of frames. Computer science students are taught to avoid frames. It is therefore problematic that the learning system promoted by the university is frame-based. It is difficult to bookmark content in individual frames. Furthermore, frames do not always display content as expected.

One reason for the use of frames in Fronter is that it allows the teachers' own web pages to be incorporated. Few practical ways exist for achieving this functionality. A widely used policy nowadays is to display 3rd party content in separate browser windows.

Another problem is that it is difficult to bookmark documents in Fronter as these bookmarks are personal. Although a document is made available to others the hyperlinks will not work as they are tied to the owners' session. Strong pedagogical reasons exist for allowing students to share bookmarks to their documents. It is technically trivial to overcome this problem. Online shops gracefully solve this problem. Shoppers can send bookmarked product links to their friends while they are logged into the system.

Several students also reported that Fronter does not fully support the Opera browser which is commonly used in Norway. Fronter is specifically designed for Internet Explorer and Firefox and the developers have decided to exploit browser specific functionality (HTML, CSSS and JavaScript)[5]. Consequently, certain user groups are excluded from the system. A public institution such as a national university should be as technology neutral as possible.

Given the fact that Fronter is password protected, users are unable to gain access without a current username and password. Password protection might be a problem for new or prospective students, as they do not have user accounts yet, but they might still want to check out the curriculum before they enroll the course. It is also hard to share information across institutions, for the same reason.

The room metaphor also makes it hard for people to participate, even if users do have a user account. To see a room, users need to be allowed access to the room. Unless users are explicitly given access, users do not even see that the room exists. Users are able to enroll a whole group of people (e.g. everyone who has signed up for the class), but it makes it hard for people to just "drop by" and take a look. If a user, for example, want a second opinion from a co-worker, that person must manually be added to the room.

CONCLUSIONS

This study suggests that students can and should be part of the assessment of e-learning systems. Assessments can be conducted as a natural part of the curriculum – especially for computer science students who should acquire the skills of expert evaluation. E-learning systems such as Fronter are in continuous development and should also be assessed regularly. Most of the students' findings are directly tied to

[5] This problem was presented to Opera Software, but since the Fronter system is password protected, it is hard for them to gain access to the system to locate the problem.

the HCI course content and many of the details are trivial cosmetic problems. However, students are trained in verbalizing the problem and suggesting improvements. In this study the students also uncovered more serious problems. The most important findings can be summarized as follows: 1) The organizational structure is not well thought trough and has grown as a result of demand. 2) The system is trying to do much more than is needed and actually useful. 3) Assignment submission is the most important component, and submitting coursework is currently too difficult. 4) Teachers should be given less freedom in how course resources are organized. 5) The developers have not been consistent and adhered to common HCI guidelines. Every revision of the system should be "proofread" by expert evaluators before the revision is deployed.

REFERENCES

[1] Hassini, E., "Student–instructor communication: The role of email," Computers and Education, Vol. 47, No., 2006, pp. 29-40.

[2] McCracken, D. and Wolfe, R., User-Centered Website Development. New Jersey: Pearson Prentice Hall, 2004.

[3] Susser, B. and Ariga, T., "Teaching e-commerce Web page evaluation and design:a pilot study using tourism destination sites," Computers and Education, Vol. 47, No., 2006, pp. 399-413.

[4] Zachrisen, B., "Evaluering av classfronter," Høgskolen i Telemark, notat nr. 5 2001.

[5] Bjarno, V., "Resultater og kommentarer fra studenter," 2004.

[6] Talberg, O., "Classfronter," 2004.

[7] Amundsen, J., Habib, L., and Harnes, H., "Prosjekt thinking, project practice: Experiences using rich pictures in a project of academic development," presented at NOKOBIT, 2006.

[8] Habib, L., "'Domestication of e-learning technologies: A preliminary conceptual framework," presented at Proceedings of the NOKOBIT 2003 conference, Oslo Norway, 2003, 24-26.

[9] Habib, L. and Johannesen, M., "Shaping or shaking the learning network? Insights into teaching practices using Virtual Learning Environments," Oslo University College, Manuscript in preparation 2007.

[10] Habib, L. and Johannesen, M., "New and Changing Actors in Teaching and Learning with Virtual Learning Environments: Insights from Actor Network Theory," presented at Proceedings of the e-Learn 2006 World Conference on E-learning in Corporate, Government, Healthcare and Higher Education, Honolulu, Hawaii, 2006.

[11] Ngai, E. W. T., Poon, J. K. L., and Chan, Y. H. C., "Empirical examination of the adoption of WebCT using TAM," Computers and Education, Vol. 48, No., 2007, pp. 250-267.

[12] Corso, D. D., Ovcin, E., and Morrone, G., "A Teacher Friendly Environment to Foster Learner-Centered Customization in the Development of Interactive Educational Packages," IEEE Transactions on Education, Vol. 48, No. 4, 2005, pp. 574-579.

[13] Hurley, W. G. and Lee, C. K., "Development, Implementation, and Assessment of a Web-Based Power Electronics Laboratory," IEEE Transactions on Education, Vol. 48, No. 4, 2005, pp. 567-573.

[14] Marín, S. L. T., García, F. J. B., Torres, R. M., Vázquez, S. G., and Moreno, A. J. L., "Implementation of a Web-Based Educational Tool for Digital Signal Processing Teaching Using the Technological Acceptance Model," IEEE Transactions on Education, Vol. 48, No. 4, 2005, pp. 632-641.

[15] Rubens, W., Emans, B., Leinonen, T., Skarmeta, A. G., and Simons, R.-J., "Design of web-based collaborative learning environments.Translating the pedagogical learning principles to human computer interface," Computers and Education, Vol. 45, No., 2005, pp. 276-294.

[16] Haffner, J. F., Pereira, L. F. A., and Coutinho, D. F., "Computer-Assisted Evaluation of Undergraduate Courses in Frequency-Domain Techniques for System Control," IEEE Transactions on Education, Vol. 49, No. 2, 2006, pp. 224-235.

[17] Hulls, C. C. W., Neale, A. J., Komalo, B. N., Petrov, V., and Brush, D. J., "Interactive Online Tutorial Assistance for a First Programming Course," IEEE Transactions on Education, Vol. 48, No. 4, 2005, pp. 719-728.

[18] Sivakumar, S. C., Robertson, W., Artimy, M., and Aslam, N., "A Web-Based Remote Interactive Laboratory for Internetworking Education," IEEE Transactions on Education, Vol. 48, No. 4, 2005, pp. 586-598.

[19] Hwang, W.-Y., Chen, N.-S., and Hsu, R.-L., "Development and evaluation of multimedia hiteboard system for improving mathematical problem solving," Computers and Education, Vol. 46, No., 2006, pp. 105-121.

[20] Tao, Y.-H., Guo, S.-M., and Lu, Y.-H., "The design and the formative evaluation of a web-based course for simulation analysis experiences," Computers and Education, Vol. 47, No., 2006, pp. 414-432.

[21] Yang, Z. and Liu, Q., "Research and development of web-based virtual online classroom," Computers and Education, Vol. 48, No., 2007, pp. 171-184.

[22] Kong, S. C. and Kwok, L. F., "A cognitive tool for teaching the addition/subtraction of common fractions: a model of affordances," Computers and Education, Vol. 45, No., 2005, pp. 245-265.

[23] Sung, Y.-T., Chang, K.-E., Chiou, S.-K., and Hou, H.-T., "The design and application of a web-based self- and peer-assessment system," Computers and Education, Vol. 45, No., 2005, pp. 187-202.

[24] Grigoriadou, M., Kanidis, E., and Gogoulou, A., "A Web-Based Educational Environment for Teaching the Computer Cache Memory," IEEE Transactions on Education, Vol. 49, No. 1, 2006, pp. 147-156.

[25] Siau, K., Sheng, H., and Nah, F. F.-H., "Use of a Classroom Response System to Enhance Classroom Interactivity," IEEE Transactions on Education, Vol. 49, No. 3, 2006, pp. 398-403.

[26] Calcaterra, A., Antonietti, A., and Underwood, J., "Cognitive style, hypermedia navigation and learning," Computers and Education, Vol. 44, No., 2005, pp. 441-457.

[27] Alexander, P. M., "Virtual teamwork in very large undergraduate classes," Computers and Education, Vol. 47, No., 2006, pp. 127-147.

[28] Kitsantas, A. and Chow, A., "College students perceived threat and preference for seeking help in traditional, distributed, and distance learning environments," Computers and Education, Vol. 48, No., 2007, pp. 383-395.

[29] Cleaver, T. G. and Elbasyouni, L. M., "Student Online Assessment Behaviors," IEEE Transactions on Education, Vol. 48, No. 3, 2005, pp. 400-401.

[30] Grabe, M., "Voluntary use of online lecture notes: correlates of note use and note use as an alternative to class attendance," Computers and Education, Vol. 44, No., 2005, pp. 409-421.

[31] Susskind, J. E., "PowerPoint s power in the classroom: enhancing students self-efficacy and attitudes," Computers and Education, Vol. 45, No., 2005, pp. 203-215.

[32] Apperson, J. M., Laws, E. L., and Scepansky, J. A., "The impact of presentation graphics on students experience in the classroom," Computers and Education, Vol. 47, No., 2006, pp. 116-126.

[33] Day, J. A. and Foley, J. D., "Evaluating a Web Lecture Intervention in a Human–Computer Interaction Course," IEEE Transactions on Education, Vol. 49, No. 4, 2006, pp. 420-431.

[34] Chen, W.-F., "Effect of Web-Browsing Interfaces in Web-Based Instruction: A Quantitative Study," IEEE Transactions on Education, Vol. 48, No. 4, 2005, pp. 652-657.