Prototype Design and Heuristic Evaluation of e-Collaboration Environment

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Abstract—**Current e-learning environment do not adequately support collaboration among students and between students and lecturers. This paper presents the design principles, prototype design and heuristic evaluation of teach, learn and research (TELEREC) e-collaboration environment for higher educational institutions. The objectives are to investigate existing design principles and didactics for e-collaboration to ascertain a realistic option for designing and developing an e-collaboration environments; second, to report on the implementation of the prototype design using a blended learning approach; and finally, to conduct formative assessment and experts' evaluation of the system. The methodological approach followed a design research approach which also integrates the values and practices of iterative development as well as user-centered design activities. The results of the study suggest that TELEREC e-collaboration environment support important usability elements such as navigability, consistency, efficiency, attractiveness, visibility and controllability as discussed in the findings.**

Keywords - e-collaboration; effectiveness; usability; didactics; pedagogy

I. INTRODUCTION

e-Collaboration is the art and science of "constructing knowledge, negotiating meanings and/or solving problems through mutual engagement of two or more learners in a coordinated effort using Internet and electronic communication" [1]. It is the use of electronic media by individuals who have common goal to achieve results [2]. Even though the concept of e-collaboration emerged with the military [3], it has since been used in wide range of sectors such as, in the industries, businesses, health, and in education. The concept is much broader than "Computer-mediated communication" [3] and mobile collaboration.

e-Collaboration supports co-laboring, co-creation, co-sharing and sees students as active partners in the community of learners, that meaningful learning occurs and that knowledge is socially produced by consensus [4]. It gives students the opportunity to learn from one another interactively, create relationship, discuss, reflect, collect and analyze information, as well as a medium for sharing resources, knowledge and information.

This calls for an effective environment for e-collaboration to occur among students and between students and instructors. It also calls for design principles, effective didactics and motivated users.

Early analysis on the students' opinions to use Social Media Technologies (SMTs) for teaching, learning and research has been conducted [5]. Our findings revealed that 74 out of 80 respondents would like to use SMTs for teaching and learning. This was followed by a proposed conceptual framework for the design and development of e-collaboration system [6]. The conceptual framework which incorporates iterative development process served as a guide in the implementation of TELEREC (teach, learn and research e-collaboration environment).

Prior research has suggested that face-to-face and traditional in-class collaborative teaching and learning methods limit learners to educator's course objectives [7], it does not allow the learner to go back and experience the class again to review and reflect on the time together with classmates and educators. More importantly, it does not cater for learners' absence, shyness and distraction. Furthermore, according to [8], the adoption of SMTs for collaborative teaching and learning is slowly emerging, while some educators are still experimenting most educators are not confident and experience in using SMTs for teaching.

The objectives of the current research are to investigate existing design principles and didactics for e-collaboration to ascertain a realistic option for developing e-collaboration environments. The second objective is to design and implement a prototype of TELEREC using a blended learning approach to serve as an effective platform for on-demand teaching and learning, collective knowledge creation, interaction and sharing in an online blended environment. Finally, this research also aims at conducting formative assessment and experts' evaluation of TELEREC.

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In order to achieve the above objectives, the researchers pose the following questions:

- What are the design principles, theories and didactic rationale for e-collaboration learning?
- How can TELEREC e-collaboration system be prototyped and implemented?
- How can the usability of the proposed system be measured?

II. Related Work

A. e-Collaboration System Development Guidelines

An ideal e-collaboration system must take cognizance of learning theories, pedagogy/didactics, learning styles, learning strategies, usability, utility, and users in order to be effective and efficient. This is because some learners find it easier to learn either individually, or in team or by practical or theoretical approaches.

1) Learning strategies and learning style

Learning strategies are methods and processes that can be applied in case of an individual learning process and this can be developed and acquired differently by different individual as it depends on their learning style which are the differences in "strengths and preferences in the way of inputting and processing information" [9] by different learners.

2) Usability

Another import issues to take cognizance of is system usability; which is the assessment of the quality, ease of use, user friendliness and how pleasant user interfaces are to users. It is "the capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions" [10]. The main goal is to identify issues and problems related to user interfaces design in the context of use cases [11]. it also allow educators and designers to identify users need to improve their satisfaction [12].

Many researchers have proposed different elements for inspecting and validating the usability of systems. According to [13], six quality components can be employed in evaluating system usability. In a study of design principles, [14] also presented five elements of user interface principles. [11] also proposed ten elements for user interface design. finally, according to [10], the ISO 25010 has characterized usability into eight sub-characteristics.

3) Utility

This is a design issue which is mainly concerned with system functionality. By this, developers find out either it does what the system should do. According to [13] "useful=usability +utility" [13]. Thus, the usefulness of a system will be ascertained from the result of both usability and utility tests.

4) Users

The importance of user in system design cannot be over emphasized. Their needs and wants need to be considered throughout the development process for them to understand and use the application. They should be involved in the design and development process. Thus, "the system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms" [10].

5) Theoretical foundation and didactics of the e-collaboration system

The e-collaboration environment is supported by five learning theories namely, the social-cognitive, situated, socio-constructivism, connectivism, and media synchronicity as illustrated in Table I.

These theories all support e-collaboration and have elements of social interaction and students' active contribution to the constructions of knowledge instead of passively receiving knowledge without any contribution of what they know, their believes and getting feedbacks from their respective actions. Table I also illustrates the didactic methods supported by these theories.

The didactics employed with this current study are exploration, problem-based learning, goal-based learning, peer collaboration and feedback from students, instructors and from the e-collaboration system. These are important to ensure authentic teaching and learning.

B. Practical Uses of Social Media for Collaboration

Many researchers and educationist have used SMTs in different ways to enhance teaching and learning particularly in a blended mode. Ioannis Giannoukos et al. from National Technical University of Athens experiment the use of wiki and forum in blended mode. Students were allowed to discuss a course related topics using forum in other to produce new educational materials which was then stored in wiki for future use. Students' activities data and questionnaire were used to evaluate the effectiveness of the system. The results shows that the methodology effectively supported group work, improve students' performance and motivation [15].

In addition, Steve Wheeler [16], used wiki and blog to support interaction and collaboration among students in a higher educational institution. Students were allowed to use their personal blog for reflection, learning diary and to post comment on others blogs. Wikis on the other hand, was use for interactive, argumentative and collaborative activities. For ease and effective use of wikis for collaboration, the author introduced a five-stage model of online learning activities. Result of the study indicated that the use of wikis and blog in teaching and learning promotes positive changes in students in higher educational institution; it enhances quality and encourages individual and collaborative learning wherever they are [16].

Furthermore, Sua et al. conducted an empirical investigation in the use of wiki in a final year dissertation module, in a BSc Information Technology degree course. Students were made to

write, post and review other's articles with the tutor's support. Their findings shows that wikis is an effective tool for collaboration [17].

On the contrary Chen et al. developed a Web 2.0 annotation system, MyNote, which allows learners to discuss, write and share notes with their colleagues and instructors. Their findings showed that MyNote support elements of usability in terms of interactivity, usefulness, helpfulness, and willingness for future [18].

III. METHODOLOGY

This study involves four set of methods: a comparative analysis of literature to ascertain design principles, an iterative development process of TELEREC e-collaboration system; a quantitative assessment relying on students' action log throughout the period of the course, and expert evaluation. In the first part of the methodology, a literature search and comparative analysis was made on design principles for e-collaboration as illustrated in Table I. The second part of the methodology employed an iterative development process consisting of four main phases (requirements gathering and analysis; prototype design and pre-release; collaborative instructional delivery; and evaluation). The third part of the method involves expert evaluation of TELEREC using a set of heuristics that consisted of 30 questions categorized under six sub headings (attractiveness, navigation, consistency, visibility, controllability and efficiency). The questionnaire is made of Likert-scale questions with 5-point preference scale (strongly disagree, disagree, neutral, agree, and strongly agree).

TABLE I. CRITICAL ANALYSIS OF LEARNING THEORIES

Learning Theory	Meaning	Design Principles	Didactic Methods
Social Cognitive Theory proposed by Vygotsky	Learning that occurs as experts and novices interact socially while focused on completing a task. The focus is on developing cognitive skills through participating in authentic learning experiences [8], [20]. Learning is believed to take place at two levels intra-psychological/individual level and inter-psychological level. Vygotsky formulated the concepts of More Knowledgeable Other (MKO) and Zone of Proximal Development (ZPD). MKO refers to anyone or machine with higher knowledge and/or skill than the learner. The MKO can be the lecturer, teacher, coach, adult, colleague or computer. The ZPD is the distance between a learner's individual development through individual problem solving and potential development through social interaction, guidance or collaboration.	• Self-publishing and reflective blogging • Interactive environments for construction of understanding. • System that encourages experimentation and discovery • Support for reflection [20] • Memory, motivation, thinking, abstraction	• Modelling • Demonstration • Explanation • Coaching • Scaffolding • Reflection • Articulation • Explorations
Situated Theory	A learner will always be subjected to influences from the social and cultural setting in which the learning occurs, which will also define at least partly the learning outcomes [20]. Learning is seen as social practice [8], [20].	• Environments for participation • Support for development of identities • Dialogue that facilitates the learning relationships [20]	• Peer collaboration • Peer contribution • Peer feedback • Comparing idea with others • Group mediated cognition [21]
Social Constructivism Theory	It views learning as the process of learners actively constructs knowledge, through achieving understanding. It enables the learner to take control of their learning. Also, knowledge construction is mediated through interaction with others and through the process of reflective thinking.	• actively involve learner • democratic environment • activities are interactive and student-centered • the teacher facilitates the learning process	• Problem-based learning • Reciprocal teaching • Goal-based scenarios • Project-based • Learning enquiry-oriented
Connectivism Theory	It emphasizes the negotiated, networked and distributed nature of learning across physical and virtual spaces. [9] • Learning and knowledge rests in diversity of opinions. • Learning is a process of connecting specialised nodes or information sources. • Learning may reside in non-human appliances. • Capacity to know more is more critical than what is known.	• Nurturing and maintaining connections is needed to facilitate continual learning • Ability to see connections between fields, ideas, and concepts is a core skill • Currency (accurate, up-to-date knowledge) is the intent of all connectivist learning activities • Decision-making is it self a learning process [22].	• Modelling • Demonstration • Practise • Reflection
Media Synchronicity Theory (MST)	It emphasize that the capability of media should support synchronicity, "a state in which individuals are working together at the same time with a common focus" [23]. It suggests two processes of communication between the sender and receiver to be conveyance of knowledge or information and convergence of meanings. "Both must occur in order to reach a group outcome. During the conveyance phase, information is exchanged. In the convergence phase, participants work together to develop a shared meaning of the information that was provided" [23].	The media should have: • Transmission Velocity • Parallelism • Symbol Sets • Rehearsability • Reprocessability	• Conveyance of information • Convergence of meanings

According to Kukulska-Hulme and Traxler, for Higher Educational institutions the maximum number for cost effective evaluation is 2-4 experts [19]. In this study, we use four experts. Finally, student action log of activities within TELEREC and other analyzes based on participation, quality of discussions, posting, responding, and feedback created were used as formative assessment. The objective is to examine the general usage of TELEREC and other online interactions during the course.

III. Results and Discussion

A. The Design and Requirement Principles for TELEREC e-Collaboration Environment

Five design and requirements principles served as guideline in the design of contents for TELEREC e-collaboration environment. These are: choice for social media technology to serve as a platform; choice for icons to serve as navigation menu; choice of class or course for the students, lecture and or tutor to use the system; usability issues to be tested; didactic or pedagogic to be employed; and supporting theories. These are discussed below:

1) Icons for interface design

Questionnaires were administered on users' choices of icons for user interface design. Students were to select the most likely representable icon for six keywords namely; privacy, contact-us, syllabus, collaboration, resources/library, and lab-exercises. After the questionnaires were analysed, the most selected icon was then used for navigation menu as illustrated in the homepage of TELEREC e-collaboration system in Fig. 1.

2) Medium and its limitation

Since there are many wiki software for developing wiki applications, this calls for researching into which is appropriate for prototyping TELEREC. A wiki choice wizard from http://www.wikimatrix.org/wizard.php was used to compare four types of wiki software before final selection of wikispaces for educators based on the fact that it is free and open sources software with supporting free hosting feature of 2GB unlimited support for formative assessment. In its support for usability, it has features for editing, templates, toolbar and WYSIWYG editor.

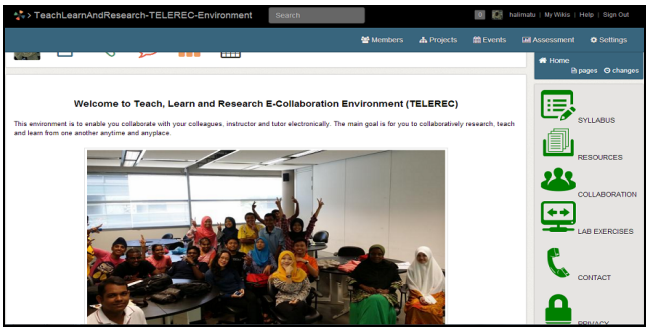

Fig. 1. Screenshot of TELEREC e-collaboration environment homepage

3) Course and group studied

Five groups consisting of six members were studied in an introduction to business information system course at the University Teknologi PETRONAS for a period of seven months. All groups voluntarily adopted and use the TELEREC e-collaboration system, which is based on wikispaces platform. Each group was able to collaboratively solve problems through dialogue, posting, discussing, sharing, interacting, creating documents and linking it to their homepage. In this environment, feedbacks were gotten from facilitator and students.

4) Usability test instruments

Comparing the usability tests components in [11], [13], [14], indicated that they have some common elements. A further comparison with the purpose of this study led to the selection of seven elements listed and described in Table II. The selected elements were then used in the design of user questionnaire that consisted of Likert-scale questions with 5-point preference scale (strongly disagree, disagree, neutral, agree, and strongly agree) and open-ended questions.

B. Scenario of Theories Application within TELEREC

The sender (instructor) create and or upload course materials like course outline, syllabus, e-books, reading items, videos, visual materials, quizzes, and assignments on class wiki, which is part of the conveyance stage. In addition to posting information on wiki, the instructor also posted problem-based scenario, case-based scenarios or questions on weekly bases for students to collaboratively solve through dialogue, posting, co-creating and co-editing using feedback from peers and instructor. This means that the receivers (students) would have to go through the convergence process by reading, interpreting, discussing, co-creating, co-editing and co-sharing contents.

Consensus is made through collective feedbacks from colleagues and or instructor. Agreement or disagreement can be discussed using class wiki directly or by using any form of

TABLE II. User Interface Design and Evaluation Principles

Usability Element	Descriptions
Simple Navigation	Navigation shouldn't be so complex and should be consistent in other not to confuse the user. This will also reduce number of keystrokes, maintain the pace of learning and retain interest of learners [14] .
Consistency	Can users use the system without being confuse with different words, situations, or actions? [13], [14].
Efficiency	Can users perform basic task as quickly as possible after they've learn the design? [13], [11]. When users feel they can easily locate and perform tasks [25].
Attractiveness	How enjoyable, pleasing and fun is it to use the system?
Visibility	The system should employ appropriate feedback to always keep users informed [11].
Controllability	Do users feel they have some degree of control and can navigate through the menu to derive useful information?

social media and later link to class wiki. The instructor or tutor then makes the final evaluation and publishing through their respective feedback. When the deadline for task activities is over no user can contribute, edit and or post solution to the problem. Another process then begins for other problems or case study.

Using the environment to demonstrate social cognitive development theory indicated that TELEREC e-collaboration environment would support individual learning through the posted resources such as e-books, slides, videos, links to quizzes and important articles. Secondly, the environment would support collaborative social interaction between students and among students and instructor. Important cognitive development will be realized through the process of more knowledgeable order (MKO).

As opposed to other theories which believes that learning takes place inside the head of individual, Siemen's believe that "we need to rely on Network of people (and increasingly technology) to store, access and retrieve knowledge and motivate its uses [24]". TELEREC environment support the ability of users to retrieve information from individual, others and SMTs.

C. The System Structure

The overall structure of the system was first considered before selecting wikispaces for use in the development of TELEREC e-collaboration environment. The structure as illustrated in Fig. 2 demonstrated that students must first of all login before accessing the homepage. Then, right from the homepage, the navigation menu has specific and different support for students and other users (lecturers, tutors, and designer). Thus, all the activities in curly-bracket-1 can be performed by students while other users can perform activities in curly-bracket-2 in addition to what students can do.

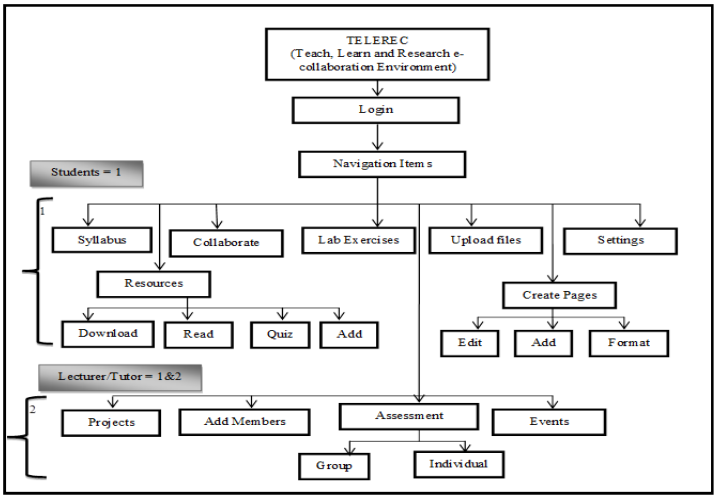

Fig. 2. Overall structure of TELEREC

D. The Prototype Design

The TELEREC e-collaboration environment is design using wikispaces for educators. This environment support e-collaboration activities through the employment of constructivist didactics methods of teaching (a teaching and learning approach which ascertains that learners have prior-knowledge/schema and that learning takes place through active participation of learners rather than passively receiving knowledge). Active participation will motivate learners, enable them to think critically, and make them independent to take control of their own learning [26]. Through collaboration they will experience others' viewpoints, discuss, discover, analyze and make a conclusive decision. They will also develop meta-cognition resulting in a motivated and independent individual. The five learning theories as described in Table I all support collaboration activities that can be applied within the TELEREC environment.

Fig. 1 is the screenshot of the homepage with menu items at the top consisting of members, projects, events, assessment and settings. The menu item at the right side bar consist of home, pages, changes, syllabus, resources, collaboration exercises, lab exercises, contact and privacy. Fig. 3 is the screenshot of individual student activities log.

E. Results from Experts Evaluation

This study involved four experts all PhD students with relevant knowledge in usability studies and Human Computer Interaction to evaluate the usability of TELEREC using a set of heuristics as described in the methodology section. After given them the access to use the system, a walkthrough of the system was conducted to get familiar with the interface. Then the set of questionnaire was given to be completed as they performed specific tasks using the system.

The result indicated that all the mean score of all the six elements are above four. The attractiveness, simple navigation and controllability elements had the highest mean score of 4.9 out of total mean score of 5. This was followed by both consistencies and efficiency with mean score of 4.8. Finally, the visibility element has a mean score of 4.7.

Fig. 3. Students activities log

IV. CONCLUSION

This study presents the design principles, models, prototype design and the results of usability evaluation of TELEREC e-collaboration system by experts. The result from experts indicated that the prototyped TELEREC e-collaboration system has met the requirement of usability elements as a collaboration tool as illustrated in Fig. 4.

V. FUTURE WORKS

Since it is always the best to evaluate user interface by employing different techniques [27], and the fact that heuristic evaluation only finds minor problems; our future work would involve conducting usability and effectiveness test using the real users of the system.

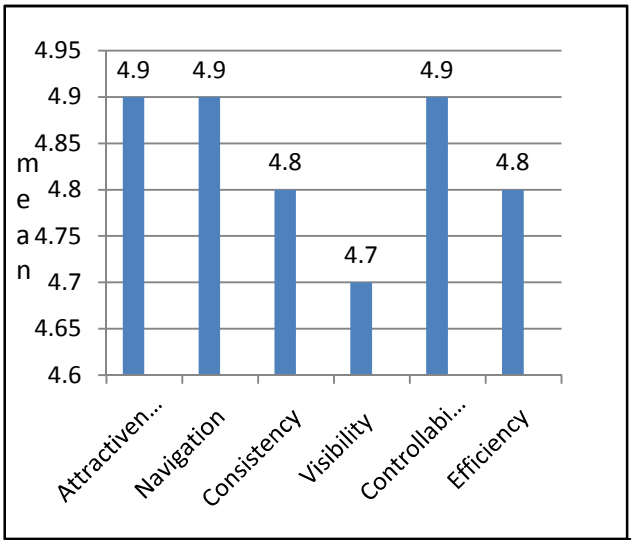

Fig. 4. Usability evaluation result

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