Universal Quadrant Model (UQM): Enhancing Usability of a Collaborative Cloud Tool for Sharing Best Practices Among Novice Users

Justus N. Nyagwencha[1(✉)] and Cheryl D. Seals[2(✉)]

[1] United States International University-Africa, P.O. Box 14634-00800, Nairobi, Kenya
justus.nyagwencha@hamptonu.edu
[2] Auburn University, 2703 Shelby Center, Auburn, AL 36832, USA
sealscd@auburn.edu

Abstract. This paper proposes and simulates an innovative approach to hierarchical group management model, the Universal Quadrant Model (UQM); a recursive, nondeterministic and backtracking generic algorithm. The model is as a result of For Youth For Life (FYFL) cloud tool research that was tasked to identify a unique solution to a problem of identifying an easy to use, scalable, cost effective, and fault tolerant collaborative system or tool for members of communities of practice to share best practices in line with Computer Supportive Collaborative Work (CSCW) field. The research was conducted in 4 phases; Phase I dealt with requirements gathering, Phase II was prototyping the system, Phase III was testing and comprehensive evaluation and Phase IV was to solve the Group Management Problem. Phase I - III problems were deciphered following the software engineering principles solutions, however, we could not find a proper documented method for managing groups spread across a spatial locality i.e. 4-H members (study group) which then necessitated the design of UQM. We consider UQM a computational framework that manages self-purporting and emerging groups and provides a mechanism that limits fictitious accounts within an online community. It estimates the number of quadrants to represent spatial locality of groups relying on population density as its main input factor. UQM is designed to cope with issues of adaptability, scalability, effectiveness, and efficiency in managing groups within a community of practice and is used for moderating users, navigation, locating and distribution of resources within an online system. The model provides a user friendly and efficient method for moderating a high number of users within groups by automating group formation. It also addresses the membership anonymity problem, and perpetuates self-purporting and sustaining groups within a spatial locality i.e. (a community of practice group). In terms of performance compared to the initial non-recursive method of group creation and management, UQM is recursive, segmenting and self-managing with a $O(n\log_4 n)$ run time. Therefore, implementing UQM presents highly significant run time theoretical gain compared to the initial solution's O(n) performance.

Keywords: Programming · User interface · Usability · WebOS (web operating system) · Communities of practice · Computer collaborative work · Secure · Access information · Technophobia · Online collaboration · For Youth For Life (FYFL) · Cloud

A. Marcus and W. Wang (Eds.): HCII 2019, LNCS 11585, pp. 472–482, 2019.
https://doi.org/10.1007/978-3-030-23538-3_36

1 Introduction

Engaging community of practice members especially a broad youth audience across this country and internationally is a tremendous challenge in today's online environment. Current and developing communication technologies offer fast paced online environments through which they can engage in entertainment, online games, social networking, knowledge searches, and other experiences.

The online learning environment is largely informal in nature in that the user explores at their initiative in a self-directed manner. It can also be formal in nature as a more deliberately directed experience with established objectives generally related to obtaining certification of some sort or a degree. Another approach combines aspects of informal and formal learning in what is known as non-formal learning with some crossover. Non-formal learning, which also includes experiential learning, for youth is the predominate form of learning in organizations such as 4-H Youth Development, scouting, and other venues that target a youth audience. Many internet sites provide learning for youth through one approach or the other.

This research explores how to provide content to the public in formal, informal, and non-formal methods through a collaborative online tool that is easy to use and learn. The research is in line with CSCW (computer supportive collaborative work) the mission of land grant universities and the U.S. Department of Agriculture (USDA). The exploration and its success is pegged on a more recent concept of e-extension that seeks for a means of extending knowledge and information in a more focused manner from the land grant university system (LGU), the Cooperative Extension Service (CES), and to some degree the U.S. Department of Agriculture (USDA) to the American public through a common online means. By engaging Communities of Practice (CoPs) online, content to its clientele or communities can be provided in a secure and user friendly manner.

This paper is organized follows: Sect. 2 gives the literature review. Section 3 outlines the approach to the Research and the basis of our research. Section 4 outlines the experiment, experimental results and analysis. Section 5 concludes and discusses several extensions.

2 Literature Review

A lot of research is focused in the area of CSCW (computer supportive collaborative work) after researchers from various academic disciplines realized that computers should be designed according to the user's needs and that various technological designs and efforts can greatly benefit from the input of others in the areas of cognitive science and humanities. This has led to a new theory and branch of computer science CSCW and user centered design.

The usage of the term CSCW inside various academic fields and fortiori across the fields is wide [3]. Beside the wide range of usage of the term, this research will focus and include specific tasks which will require member participants to converge to a shared understanding of CSCW among members of communities of practice for the purposes of collecting data, analyzing, and evaluating it to ascertain the impact on

subjects. The study chooses to utilize a cloud based tool to support communities of practice in a method that is user friendly, secure, efficient, effective, and ease of use compared to most social CSCW networks systems. This work is inspired by the appeal of Facebook and its ease of use. The motivation is to create an environment that will support a large community of practice in virtual space. The environment will encourage K-12 teachers and 4-H members to share and re-use best practices in the initial phase.

CSWC is an area of study with numerous unexplored benefits for a cross section of the population groups [2, 3]. For example, through CSWC K-12 teachers can be encouraged to share and re-use best practices as a community of practice (to emulate) the business industry which has highly benefited from sharing best practices through collaboration (e.g. the software development industry that successfully utilizes code-re-use during software development through collaboration). This project aims at evaluating and validating a tool or framework that can be used to encourage sharing of best practices within a community of practice to steadily benefit and enhance member's career aspirations through CSCW as witnessed in the code-re-use within the software development industry [5]. The research will validate the need to incorporate a tool to support virtual communities to share and re-use of best practices and take advantage of the numerous benefits offered by the CSCW tools. This work will be validated through surveys about the FYFL cloud and a virtual community that has been developed in our HCI lab in collaboration with the Alabama e-extension department. The research findings are aimed at highlighting the following benefits of collaborating through the secure CSWC tools verses traditional methods. These benefits include:

1. Possibility to Communicate Effectively
   There is a high a possibility for members of a community of practice to learn how to communicate effectively, by reaching out to each other and building trust and understanding through friendships by seeking common ground [5, 6].
2. Motivation to Collaborate
   Members of community of practice groups will build a sense of responsibility by feeling obligated to the group and will take responsibility for the group. In due course they will learn to be responsible and become team players with the skills necessary to succeed in today's world [5, 6].
3. Secure and Efficient Access to Information
   Members of community of practice will access information and other resources easily without the restriction of time and place, unlike the prevalent face-to–face collaboration system. In addition the permanency of records on shared practices, the independence of time and place to access information will allow members (e.g. students, teachers, and 4-H members) to learn and complete the tasks at hand remotely. This will also eliminate the fear of starting from scratch when the need for a practice arises and encourage members to focus on the task at hand [5, 6].

In this research, a CSCW cloud tool was used and evaluated by authors as an effective secure online tool for sharing best practices. The study investigated and focused on usability and security issues that affect online environments. The evaluation was to ensure that the tool met minimum online usability standards and had robust security to safeguard member privacy. The process utilized HCI techniques and design

guidelines gathered feedback on how to improve the initial system from usability experts, K-12 teachers, 4-H members who were nominated as the initial user test population. The survey responses provided valuable input for re-designing user interfaces and re-affirmed security concerns as a major issue among novice computer users. However, issues concerning security and how it relates to HCI will not be addressed in detail in this research.

The main goals of this research were to examine the issue of providing a collaborative tool to support communities of practice members engaged in informal learning online and propose a group management model for emerging groups by combing an informal learning and spatial locality theories. We relied on CSCW usability evaluation acceptance test approach necessary to effectively provide an environment feasible to accommodate and support novice users. The work resulted into a FYFL cloud tool to support communities and a model to foster and manage emerging groups relying on literature reviews on collaborative theory and online group principals. Our recommendation is a first attempt supported by empirical usability and acceptance tests data from focus groups on online collaboration and information learning.

Thus, the research utilizes a cloud tool (FYFL) and focus groups to validate a CSCW tool in relation to (1) sharing and re-use of best practices, (2) justify the usability of the selected collaborative tool (FYFL) and the effects on novice users.

3 The Approach to the Research

This study has identified K-12 teachers and 4-H club members as the initial subgroups. The main criterion for choosing members to participate in the study is a voluntarily acceptance of teachers and schools to participate by willingly subscribing to use the FYFL cloud tool to collaborate and share best practices. Participants provided a feedback on its usability, efficiency and suitability for collaboration purposes.

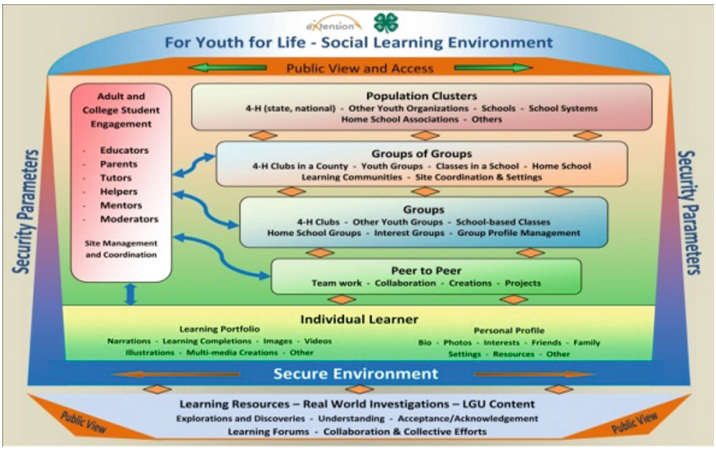

Fig. 1. The Initial For Youth, For Life theory – The Envisioned Secure Social Learning Environment Copyright. © 2009 Auburn University, Alabama Cooperative Extension System.

The 5 main goals of the study are:

1. Select an appropriate secure tool for CoP to share best practice for available utilizing an expert inspection and feedback report.
2. Configure the secure tool to accommodate the user group in accordance to software engineering principles.
3. Come up with a minimalist tutorial for the redesigned tool.
4. Conduct a usability and acceptance test with the test group before deploying the tool.
5. Design a usability management model for group formation and perpetuation.

Thus the study aims to encourage and promote the informal learning through a new environment for collaboration among groups of CoP. We hope to accomplish this goal by focusing on the usability of the tool because a previous survey conducted among the K-12 teacher population in the initial stages of this study, concluded that teachers will utilize the prototype tool only with improved usability. To ascertain the usability of the selected tool, a broad array of questions to be answered by the experimental participants were created to gather data for the research through a survey. The survey required a user to identify themselves as a novice or having advanced computer skills for the purpose of

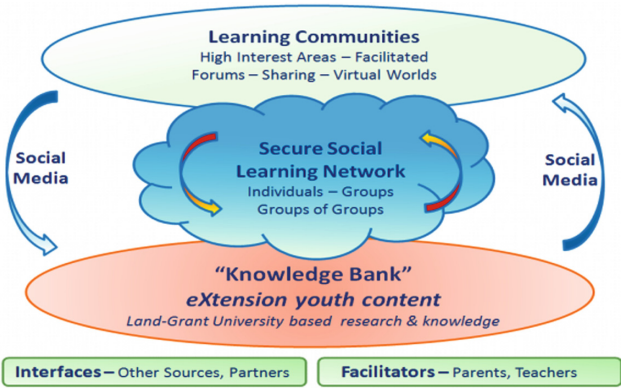

Fig. 2. The revised and improved Social Learning Environment theory Copyright © 2010 Auburn University, Alabama Cooperative Extension System

assessing the usability level of the tool and its impact on subjects (Fig. 1).

The study was broken into three phases as outlined below to gather requirements, create a prototype and conduct a comprehensive evaluation of the system. During evaluation, subjects were given a minimalist tutorial to utilize to perform a series of tasks and at the end of the list of tasks they completed a detailed survey questionnaire to provide feedback on their experiences with the system.

3.1 Phase I: Requirements

Requirements were gathered in phase I of the study to assemble the building blocks for the system. A thorough scenario based usability, security inspection and analysis approach ensued on the existing tools/software to identify the best suited tool to support the gathered requirements.

3.2 Phase II: Prototyping

Guided by the requirements, the team selected two suitable tools and modified them for evaluation. The resulting tool received a prototype step through scenario based usability, security inspection and analysis from the experts group. The modifications were necessary before testing with the potential users in line with CSCW guidelines. The requirements served as foundation for an iterative design and development work for the desirable community of practice tool in Phase III.

3.3 Phase III: Testing and Comprehensive Evaluation

A comprehensive analytical and empirical analysis gauges the success of the collaborative tool to support informal learning among CoP groups. The process included a comparative expert security and usability inspection of the selected and modified tool, usability and acceptance survey test of the FYFL by potential users, and a detailed qualitative and quantitative analysis of results from study. The expert evaluation stages were meant to produce results leading to the answers to the research questions while potential user's data served as a guideline for measures to be taken to improve the overall usability and acceptance of the cloud tool.

Thus, the study adopted a cloud environment to leverage existing tendencies of human social nature and utilized it to enhance a collaborative environment based on the expert recommendation after reviewing more than a dozen tools. We anticipated that the participants of this work will have improved efficacy of their computer literacy, improved educational performance and more intrinsic motivation to spend more time concentrated on efforts that promote scientific content materials at the end of the study. In the second phase of the study, participants will work together as teams in a community of practice (e.g. student and teacher teams) that will utilize and contribute to this sharing and learning environment [1]. The usability and acceptability results of this study support the creation of an environment that supports communities of practice in creating and sharing more content materials in a virtual community in a cloud environment as outlined in Fig. 2. Our hope was that this method of resource presentation will increase the usage of educational materials and applications among community of practice members in line with HCI and CSCW research. The environment will support improved use of materials within the virtual community leveraging the ease of use and popularity of other social networking environment such as Facebook with enhanced security.

3.4 Phase IV: Group Management Problem

Managing 4-H members spread across wide region i.e. a state is challenging and poses an insider threat problem for users. To alleviate this problem, a formal model to manage this complexity is required to allow administrators to effectively navigate and locate resources within the system. For example, it is easy for an individual to moderate 100 members in a group, but intractable to navigate if the groups grows and surpasses 10,000 members within a spatial locality. To moderate a topic or a discussion among thousands of members by a single administrator is not solved through the currently available method. The model is effective in managing registered members through an appointed group leader. But, it is overwhelming for one administrator if the member's population exceeds a certain threshold (P), since the current system doesn't focus on monitoring and moderation of members activities in case there is an influx of member subscription.

Our analysis on the current solution reveals that it is intractable, static and lists all members in a single list without associating them to groups automatically. The model is 100% dependent on the administrator to create and assign registered members to specific groups/various groups manually. This method is recommended for possible for managing groups with a small number of users i.e. $N \leq 1000$ but is intractable and inefficient for a bigger N (i.e. $N > 10000$). Thus, the existing model does not support self-purporting and sustaining groups important for the success a collaborative tool to foster informal education among members of communities of practice.

4 The Universal Quadrant Model and Simulation Results

To overcome the $N > 10000$ limitation imposed on our earlier solution, we initially suggested solution for managing groups of groups. The solution involves listing/creating regions based on the political boundaries and alignments in the United States. The four regions (North East, South, Midwest and West), being the cornerstone and further delaminate the rest into states followed by counties. This is a practical solution, however it has it has it discrepancies. For example, some counties may not have clubs and will lead to dummy clubs without members and could affect the search process when N- is greater. Thus, it makes it an inefficient solution for a group problem. On the other hand, the formation of groups and management of posts is entirely depended on an administrator who should assign then manually an impractical task for an $N > 10000$ especially even considering having many administrators. Doing business this way, will slow the group formation process as well limit sharing of information on the cloud forum. Therefore, this is not an optimal solution for the group problem. It has a color coded interface; but doesn't automate the process or aid in the process of creating self-purporting and sustaining groups. It is an intractable solution

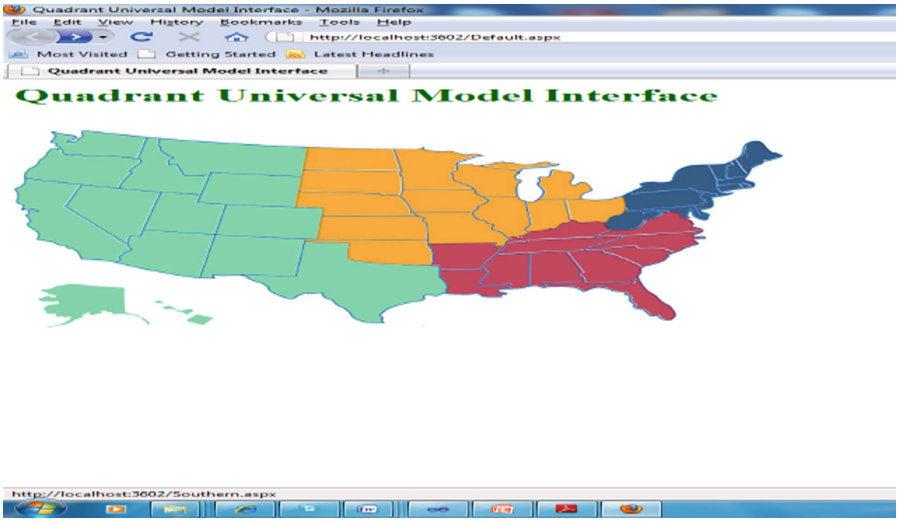

Fig. 3. Conceptual prototype for color coded regions

with an influx with members joining various groups. The solution's prototype is illustrated in Fig. 3. A conceptual prototype of the existing membership and group model supported by a data structure list with O(n) run time is represented by Fig. 3.

Our solution the UQM (universal Quadrant Model) improves the current model by providing a way to alleviating the fictitious membership's problem and promoting self-purporting and sustaining groups. The model allows vetting of memberships by associating applicants with spatial locality groups as well provides a graphical interface for easy management of those groups.

We propose a Quadrant Universal Model algorithm to address the problem. The algorithm will in addition address the membership anonymity problem, perpetuate new manageable groups within a spatial locality and associate it with the original group once a certain membership threshold is reached within a specific quadrant or region.

Managing individuals, groups, and groups of groups geographically (globally) in a less costly, manageable, predictable manner is NP-complete problem without an exact solution. However, the proposed set theory quadrant universal model (QUM) simplifies the management of individuals, groups, and groups of groups spatially and overcomes overlapping of memberships within groups.

QUM is a recursive, nondeterministic, backtracking algorithm that finds all solutions to number of quadrants needed to be represented by spatial locality groups based on the population. The goal is to select a subset of the quadrants and classify them based on geographical location and population density or count. This is meant to ease moderation and elicit training alerts of moderators when need arises (Fig. 4).

Compared to the initial method, UQM is recursive, segmenting and self-managing with $O(n\log_4 n)$ run time compared to the initial solution's O(n) run time. Thus, implementing UQM presents highly significantly run time gain theoretically (Table 1).

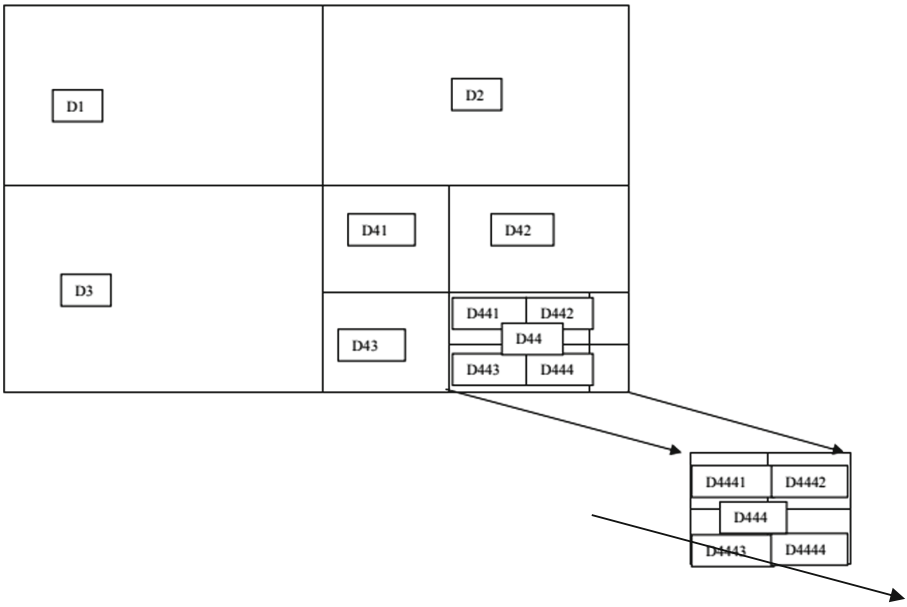

Fig. 4. This is an illustration of the UQM creating new groups recursively.

Table 1. Proposed UQM algorithm is a Tree structure with $O(n\log_4 n)$ run time.

Algorithm UQM functions as follows:

1. If the quadrant Q is empty, the problem is solved; terminate successfully.
2. Otherwise choose a quadrant (Q) NW, SW, NE or NW (deterministically).
3. Read P, total 4H members P, P-4H members population
4. IF P < threshold
5. Include quadrant in the partial solution.
6. For each quadrant such that P > threshold,
   Divide quadrant into NWi, SWi, NEi, SEii = 1
6. Repeat recursively on the reduced quadrant Q.

The extended Universal Quadrant Model implements and defines a user interface for group creation and group management. The simulation which is an extension of the theoretical model provides a login user interface, a color coded group interface for users and managers to visually locate, view, monitor membership group status and determine those ready to split. Having such information at a glance will aid in the process of identifying a leader for the newly created groups. We believe that the color coded user instances, is an improvement on the previous solution which did not have a means of issuing a warning to managers on the size of groups in question.

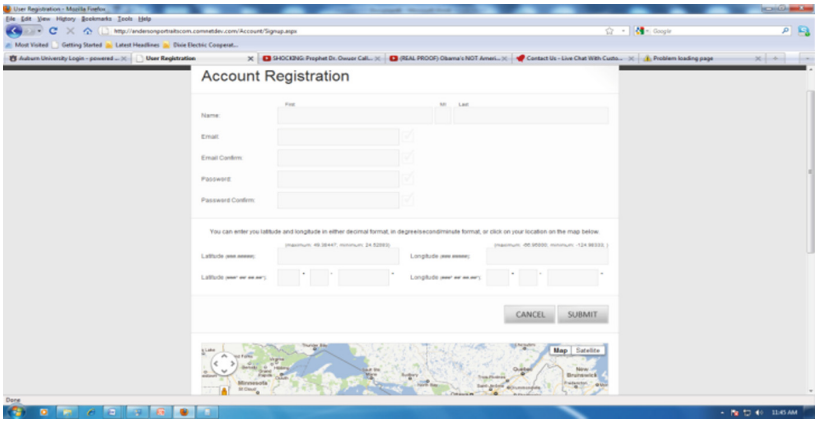

Fig. 5. UQM prototype account registration page

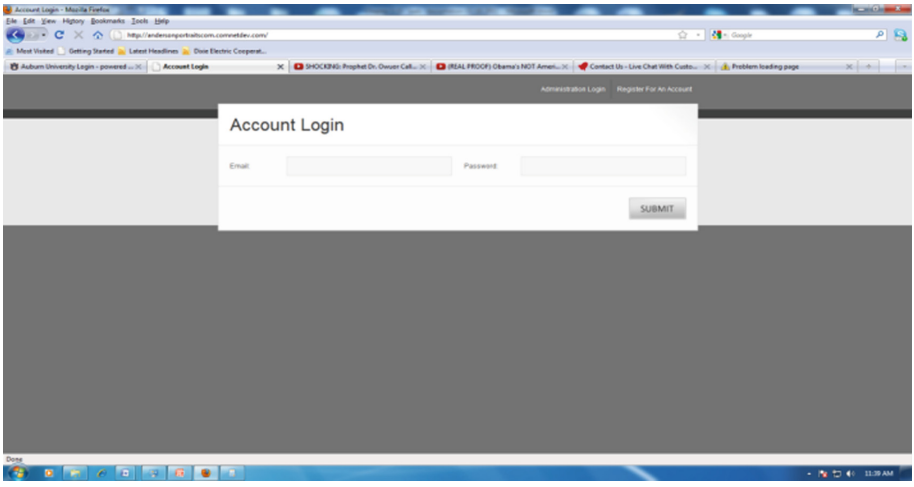

Fig. 6. UQM prototype account registration page

Figure 5, the account registration page uses Google maps for users to sign up and identify themselves in relation to a spatial locality of individuals by entering the latitude and longitude coordinates in the database of the current address and club.

The Information is fundamental in determining which group to be assigned. The process is automated and helps in creating groups as well as maintains accuracy for members since potential members will be vetted by an existing member of their local club limiting the number of false accounts significantly (Fig. 6).

The UQM supports the Table-Insert and Table-Delete. The Table-Insert inserts onto the table an item that occupies a single slot space for one item. Table delete can be thought of as a removing an item from the table.

5 Conclusion

The adoption and success of an informal educational cloud tool depends entirely on its security and usability. Computer supportive collaborative work and human computer interaction theories provide usability acceptance test knowledge that can support the effective user evaluation and acceptance tests of collaborative tools. However, the formulation of an effective and efficient acceptance testing process is made difficult by the plethora of design theories and models that outline how support a novice user in understanding and using a collaborative tool to share best practices without compromising its security. The premise of this research was that user acceptance test and expert analysis can provide a mechanism for identifying a suitable secure CSCW tool that is understandable and easy to use for a novice user. We base the practicality of this approach to the previous research efforts in using human studies and expert feedback to test the suitability of software products before deployment.

Initially our efforts were focused on identifying a viable tool for communities of practice to share best practices but later ventured into defining a model to aid in managing groups of groups that emerge within the online community while protecting the integrity of the community. The security analysis expert survey selected the FYFL cloud tool among other potential candidates and it been validated through an acceptance usability survey data from potential users. On group of group management, the universal quadrant model will be incorporated once it's fully tested by refining the existing cloud tool (manual) group management feature to create an environment that supports self-purporting and sustaining groups for both development and design users within the cloud.

The contribution of this research is beneficial to computer supportive collaborative work (CSCW) design, human computer interaction research, online group theory research, green computing and informal learning research, and usability studies research. Our major contribution is we also the proposed group management model "universal quadrant model (UQM)" aimed at mitigating insider threat within virtual groups and is validated through a simulation.

References

1. Cain, C.: Social networking teaching tools: a computer supported collaborative interactive learning social networking environment for K-12. Maters thesis, Auburn University, Auburn, AL (2010)
2. Diaz, D.P., Cartnal, R.B.: Comparing student learning styles in an online distance learning class and an equivalent on-campus class. Coll. Teach. **47**(4), 130–135 (1999)
3. Dieterle, E.: Handheld devices for ubiquitous learning. In: ISTE Conference. ISTE, Portland (2005)
4. http://link.wits.ac.za/papers/e-index-tanzania.pdf
5. Fahræus, E.R.: Collaborative learning through forum systems – problems and opportunities. Electrum 230, S-164 40 KISTA, Sweden (2000)
6. http://www.answers.com/topic/semiotics
7. Rosson, M.B., Carroll, J.M.: Usability Engineering. Morgan Kuafmann, San Ndiego (2002)
8. Dillenbourg, P.: What Do You Mean by Collaborative Learning: Cognitive and Computation Approaches, pp. 1–19. Elsevier, Geneva/Oxford (1999)