The Migration and Growth of a Scientific Learning Community

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ABSTRACT
Early results from a long-term programme of evaluation of the development of the VirRAD online learning community, for the Nuclear Medicine community, are presented. The first results, using a modified version of an extant framework to monitor communication activity show that this has yet to develop, but factors contributing to development have been identified. Results from an additional study provide encouraging predictions of users' likely acceptance of the community. A relationship between users' 'sense of virtual community' and acceptance has been observed. Recommendations for further work are made in order to confirm the existence and nature of the relationships found.

Keywords
Online communities, acceptance, evaluation, communication analysis, sense of community.

INTRODUCTION

Previous Research
Networked learning environments, such as online communities, can provide the stimulus for knowledge exchange and opportunities for research collaboration for geographically distributed communities of professionals. The VirRAD environment centres on the provision of a learning community, combined with multimedia courseware and a virtual reality laboratory. This environment is designed to encourage participation through its incorporation of a variety of functions, including discussion forums and chat rooms, virtual conferencing facilities and databases of relevant information. Although physical communities of practice have been well studied (see for example, Wenger, 1998 for a review), little is yet understood about such virtual counterparts as VirRAD, and how they can be designed to be successful.

Some research has been conducted in order to determine factors that contribute to the successful development of virtual communities of interest (Whittaker, Terveen, Hill and Cherny, 1998; Butler, 2001; Schoberth et al., 2003). Schoberth et al. (2003) describe a longitudinal study conducted over three years which examines the development of a virtual community of interest. Based upon two studies (Whittaker et al., 1998; Butler, 2001) investigating how different factors affect the sustainability and interactivity of online communities of practice, Schoberth et al. (2003) develop a conceptual framework through which to analyse the communication activity of online communities. The framework attempts to analyse community users' communication activity through such measures as relational and attributive activity and communication strategies. They propose that a combination of factors can be used to explain communication activity, including 'common ground', community size, community activity, 'information overload', user experience and domain specific external influences.

Common ground, the degree to which participants share mutual knowledge, beliefs and assumptions, is believed to provide the basis for interactions between individuals in a community and was found to be affected by community size and the familiarity of its members with one another (Whittaker et al., 1998). Common ground was also found to be a predictor of the relational activity, or interactivity, of communications. Increases in community size and activity were found to cause information overload, whereby users are overwhelmed by information, resulting in shorter message postings (Schoberth et al., 2003).

Previous research has focused on online 'communities of interest', but there has been little investigation of the development of online professional communities of practice, in which participants are principally involved to support their working or studying practices. Participant motivations in such communities are likely to be different to those involved in communities of interest and as a result, the main determinants of growth for online communities of practice may be different from those identified for communities of interest by Schoberth et al. (2003).

Schoberth et al. (2003) make predictions about the perceptions of the community participants through an analysis of the evolving communication activity that occurs between them. However, it has been suggested (Preece, 2001) that in order to make a full evaluation of a community, the extent to which the community addresses users' requirements should also be explicitly considered. An indicator of the degree to which users' requirements are satisfied by a community would be their acceptance of it. Dillon and Morris describe acceptance as 'the demonstrable willingness within a user group to employ IT for the tasks it is designed to support' (Dillon and Morris 1996). In order to measure user acceptance, Davis (1993) developed the Technology Acceptance Model (TAM), which determines users' acceptance of systems by using the constructs of ease of use and usefulness as perceived by the users. However, this model has not yet been validated with an online community.

In physical communities, participants' feelings of connection and belonging to a social group, or "psychological sense of community" (McMillan and Chavis, 1986), are considered to be important for the development and long-term success of the community. Recently, Ng (2001) has also noted the importance of sociocultural factors in online communities, stating that online communities have the potential to "promote collaborative learning only if participants can relate to one another, and share a sense of community…" (p. 199). Recent studies have shown that members of both online communities of interest and virtual communities of practice *can* feel a "sense of virtual community" (SOVC) (Blanchard and Markus, 2002; Kruger and Shriberg, 1999). They considered factors including members' feelings of belonging to the community and their influence over it, their shared emotional connections with others and the extent to which members' needs are fulfilled within the community. However, work to date has not considered the role that users' SOVC plays in the early development stages of a virtual community or, indeed how this contributes to participants' acceptance of the community.

Objectives

An existing e-mail discussion group (RadPharm) has attracted six hundred radiopharmacists and related professionals. However, this group, originally intended to promote interactive discussions, was functioning only as a mailing list. Members of RadPharm are therefore being encouraged to *migrate* to the VirRAD learning community. Exactly how successful this will be remains to be seen, but we see a number of potential difficulties, such as access to networked computers in the workplace. The extent to which VirRAD will be accepted by its potential users is clearly critical. In this study we were interested in making some predictions about acceptance to inform the design process and in recording the actual level of acceptance.

This study is part of a broader programme of formative and summative evaluation which was developed as an integral part of the project. The formative element of the study plays a key role in the ongoing development of the community, by feeding back results to the development team. The summative evaluation has broader concerns; it examines the long-term development of the community in order to provide information about how to use the training elements of the community in training situations, and to make some general predictions about what factors contribute to the development of successful online communities. Accordingly, we monitor the community membership, community size and communication activity within the community, both for individuals and between individuals, in order to assess the growth and development of the community.

The three central objectives of this research are:

- To study users' acceptance of the community in terms of its usability, usefulness, and users' SOVC.
- To examine the growth of the community through the pattern of communication activity over time.
- To attempt to identify factors contributing to the growth of the community.

Conceptual aims

The part of the evaluation described in this paper utilises two conceptual frameworks. The first concerns user acceptance of the community. The TAM (Davis, 1993) is utilised. This focuses on two constructs: perceived ease of use and perceived usefulness. Perceived ease of use concerns users' perceptions of the usability of the community. Usability is a construct which relates to the ease with which a computer application can be used to perform the tasks it is designed for. It is typically defined in terms of the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" (ISO/IEC, 1998b). Effectiveness concerns whether the users can perform their required tasks. Efficiency concerns the resources they must consume to achieve their tasks, and satisfaction concerns the extent to which they actually liked using the application to perform those tasks. The notion of task is central to this

conception, and our evaluation approach emphasises the need to relate usability evaluation criteria to specified tasks. To this model we add the notion of the users' SOVC. We use this to investigate users' predictions of such factors as feelings of belonging to the community, influence over it, shared emotional connections with others and the extent to which members' needs are fulfilled within the community. We wished to examine how these factors may manifest themselves, if at all, when both the community and the communications between members are better established over time.

The second part of the study concerns itself with the framework proposed by Schoberth et al. (2003), in which a range of metrics that describe the activity and, in particular the interactivity, within the community are logged. This framework proposes a combination of metrics which can be analysed to determine the interactivity and communication strategies within the community.

METHODS

The formative evaluation uses a range of methods and instruments, not all of which are discussed here. The key elements are a set of instruments designed to measure the various elements of the TAM model, and a series of logs of data from the community itself which are based on the metrics identified by Schoberth et al. (2003).

Acceptance

A variety of data was collected, both quantitative and qualitative, to measure the acceptance of the learning community. Users' perceptions of the learning community and their experiences with it, including its usefulness and ease of use were gathered (Davis, 1993), along with their predicted SOVC (Blanchard and Markus, 2002). These studies of the perceived quality of resources in the community (including members' communications) and the social aspects of the VirRAD learning community provide information about the added value of the VirRAD learning community and suggest its potential for supporting learning. Additionally, conclusions may be drawn from these findings about the extent to which the learning community achieves its aims and, therefore, whether the migration of members to it was worthwhile. It may also provide persuasive evidence for those that have not already participated in migration. This part of the study was conducted in three phases.

The first phase was conducted before the community was launched to a wider audience, with the VirRAD User Group, a representative sample of eleven practitioners, trainers and recent students who were recruited to provide feedback at a number of points during the project. Data on a number of aspects of the community was collected from this group using three different methods; observations, and individual and group interviews. User observations were conducted which centred on a set of tasks to perform within the community. Users worked in pairs to encourage 'thinking aloud', an established method within psychology and cognitive science, for assessing users' thoughts whilst interacting with a system (Lewis and Rieman, 1994). Pairs were chosen on the basis of similar experience and ability in terms of their computing skills. One participant worked alone, due to the odd number of User Group members attending, and was encouraged to verbalise his thoughts. A debrief interview was used to investigate some aspects of perception and attitudes, but was also useful in following up points and issues raised during the observation session. The debriefing took place immediately after each observation session and involved a short discussion between participants and observer using a few common questions for all pairs supplemented by questions based on events during the preceding observation session. User Group members also participated in a group interview, designed to elicit more general views of the community, including its potential usefulness and obstacles to usage for the radiopharmacy community, and suggestions for its improvement. This took place the day after the observations were completed. A selection of pre-planned questions was used by evaluators to stimulate discussion.

The second phase of the acceptance study utilised a questionnaire to examine the usability of the system with a larger sample of users after the launch of the community. This questionnaire asked participants to rate, on a five-point Likert scale, the extent to which they agreed or disagreed with a number of statements based on a set of usability constructs. These included learnability, memorability, navigation, adequacy of system feedback, general pleasantness to use, aesthetics and user control. Fifty-five users of the community (20% of the current membership) were randomly selected and invited to participate. All questionnaires were distributed as an email attachment.

The third phase was also a survey of members of the community after its launch, but focused on users' acceptance of the system. Another fifty-five users were randomly selected from the remainder of community members (after sampling the above users, without replacement). Questions on users' perceptions of the usefulness and ease of use of the community utilised Davis' concepts of 'perceived ease of use' and 'perceived usefulness' (Davis, 1993). We also asked about predicted future usage. In addition, a number of questions to

assess users' SOVC predictions were developed, based upon the explanatory framework proposed by Blanchard and Markus (2002). These explored the constructs of members' feelings of belonging to the community and their influence over it, their shared emotional connections with others and the extent to which their needs are fulfilled within the VirRAD learning community.

Logging community use

This study was originally planned as part of the summative evaluation process and was not intended to provide early insights of a kind useful to the formative evaluation. However it was felt that logging at the formative stage would: a) strengthen the data available for iterative development of the software after the initial launch; b) provide empirical data on acceptance; and c) give a more complete history of the development of the community for the summative evaluation studies. In addition, the early development stages of the community were of interest as there is no research (to our knowledge) which examines the communication growth of an online professional community of practice.

This study involves monitoring a number of areas of communication activity using automatic logging. We have developed a set of metrics based on the conceptual framework proposed by Schoberth et al. (2003). These measure such factors as relational and attributive activity, community size, external influences, communication strategies and user experience. Additional metrics have been developed from previous research attempting to quantify community interactions in order to assess the 'health' of communities (Bowes, 2002; Whittaker et al., 1998). In the development stages of the community, metrics are being monitored on an approximately weekly basis. A selection is included in the Table One, below:

Construct	**Measures**
Demographics	1.Number of registered users 2.Number of new members 3.Number and percentage of active and inactive users
Community Activity	4.Number of new news items posted 5.Number of events listed 6.Number of new topics created 7.Number of new messages posted
Relational Activity	8.Number and percentage of new topics without replies 9.Mean number of replies to all topics, new and old 10.Number and percentage of active and inactive topics 11.Mean length of new messages posted
Attributive Activity	12.Mean percentage of replies by topic author for every topic 13.Mean number of postings per active user 14.Number of individuals posting 1, 2, 3, 4, 5 or more messages 15.Number of first-time posters and their mean membership duration

Table 1: A selection of the metrics used to monitor the communication activity in the VirRAD community.

Data analysis

Acceptance

Observations and interviews were recorded using audio, and in one case, using video. Observers also made a written record of participants' interactions throughout. The resulting qualitative data was analysed by categorising incidents, comments and other observed phenomena. The coding was generated from the data rather than from pre-selected categories.

Twenty-six completed usability questionnaires were received. Scores across all constructs were summed to give a total usability score. Statistical testing was conducted. The ease of use, usefulness and SOVC questionnaire received twenty-five responses. Participants were also asked to give an indication of their likely future use,

which was taken to be their predicted acceptance score. Ease of use, usefulness and SOVC total scores were also used to predict acceptance. Statistical testing was conducted.

Community logging

Community logs have been taken at a number of intervals and began about three months ago. We analyse the data using time as a discrete variable (as in Schoberth et al., 2003) and plot the activity variables against time using scatterplots to enable comparisons to be made about communication activity as it changes with time.

RESULTS

Acceptance

Results from the observations and debrief interviews suggested a number of improvements to the community. Several users had difficulty understanding some of the community functionality and the lack of transparency of the information structure did not allow the majority of users to navigate the community with ease in what was their first instance of use.

The focus group explored a wide number of issues. It was agreed by the group that VirRAD should be 'all-encompassing', featuring links to resources that are indispensable in their workplaces, in order to ensure use and to enable the growth of the community. It was agreed that VirRAD must be seen to evolve and to be updated regularly so that people are encouraged to keep visiting the site and a suggestion was made to expand the information databases and resources.

In response to questions about the usefulness of the community the focus group felt that it would be useful, and it was felt by one member of the group that VirRAD would be the prime and therefore most important means of communication for the radiopharmacy community. A number of obstacles to usage were discussed. Time was considered to be the main obstacle and internet access was thought to be an issue in some areas of the world. A significant obstacle was thought to be faced by people with difficulties with the English language, as this is the designated language of the community.

Results from the usability questionnaire, for each of the total constructs, are shown in Table Two.

Constructs	N	Minimum	Maximum	Mean	Std. Deviation	Mean Score per Question
Total General Attitude	25	13.00	30.00	22.88	4.17	3.81
Total Learnability and Memorability	26	8.00	29.00	21.46	4.79	3.58
Total Navigation	18	22.00	44.00	33.61	6.30	3.73
Total Control and Feedback	26	10.00	24.00	17.35	3.62	3.47
Total Help and Documentation	18	12.00	25.00	18.33	3.46	3.67
Total Aesthetics	26	2.00	10.00	6.92	2.26	3.46
TOTAL USABILITY	17	96.00	174.00	136.47	22.79	3.69

Table 2: Descriptive statistics for each of the usability constructs.

The distribution of total usability was normal, with partial negative skewing and very high positive kurtosis, indicating that responses were focused around higher scores of usability. Cronbach's Alpha analyses indicated that all constructs reached very high significance for internal validity, so it was likely that each question was measuring the appropriate construct. The highest score (when comparing mean scores per question) was given by participants' for their general attitude towards the community, with fifteen of the twenty-five respondents strongly agreeing and eight agreeing that they would recommend VirRAD to their colleagues. There were only two attitude statements for which the mean response was below three, indicating negative responses. These statements related to difficulties in finding things in the community and the need for more information or training when using the community. This indicates that these areas may be problematic for users, and so improvement work should focus on these areas to improve overall usability of the community.

Results from the acceptance questionnaire are provided in Table Three.

Constructs	N	Minimum	Maximum	Mean	Std. Deviation	Mean Score per Question	Percentage of Positive Responses
Predicted Future Use	25	2.00	5.00	4.16	0.80	4.16	84.00
Total Perceived Ease of Use	21	20.00	42.00	33.19	5.59	3.69	78.26
Total Perceived Usefulness	23	25.00	49.00	36.26	5.92	3.63	80.95
Total Predicted SOVC	24	33.00	53.00	41.17	5.16	3.74	91.40

Table 3: Descriptive statistics for each of the acceptance constructs.

Twelve of the twenty-five respondents to the acceptance questionnaire agreed and nine strongly agreed that they 'would use the community regularly in the future if it was available to them at their place of work', a very good indication of future acceptance. The constructs of 'perceived ease of use', 'perceived usefulness' and 'predicted SOVC' all had high internal validity, reaching significance with values of 0.87, 0.91 and 0.86 respectively; that is the questions used to measure the constructs were likely to be measuring those constructs. As shown in Table 3, the mean scores for each question, for all constructs were high. Even with relatively large standard deviations, the majority of respondents are answering positively upon inspection of the total scores for each construct, as can be seen by the last column in table 3 (this is calculated by obtaining a mean score for each of the questions measuring each construct). Those obtaining a mean score above 3 (a positive rating on the Likert scale used for each attitude statement), were said to have made overall positive responses for the construct.

To further investigate these constructs and their relationships with 'predicted future use', a multiple regression analysis was conducted. Results indicated that the three independent variables, 'perceived ease of use', 'perceived usefulness' and 'predicted SOVC', jointly predict 47.1% of the variance in the dependent variable 'predicted future use' [$R^2 = 0.471$, $p = 0.04$]. However, none of the independent variables were found to make a significant *unique* contribution to future usage predictions. These results suggest that there are overlaps between the variables and some of their effects may be mediated through one another. This is supported by partial correlations which show that none of the variables have a lone effect on 'predicted future use'; 'perceived ease of use', 'perceived usefulness' and 'predicted SOVC' only have a significant effect on 'predicted future use' when in combination with another variable. With the possibility of overlap in the independent variables and the small sample size used, it is more accurate to report the non-parametric correlations, as given by the Spearman's rho statistical analysis technique. All correlations between variables were significant (except that for 'perceived ease of use' and 'predicted SOVC') and indicate that 'perceived usefulness' correlates with 'predicted future use' more positively ($r = 0.735$, $p = 0.000$) than 'perceived ease of use' ($r = 0.559$, $p = 0.008$). Davis (1993) suggested that 'perceived ease of use' has an effect on future use *through* 'perceived usefulness', which would explain these results.

Community logging

The log files have been collected for three months at the time of writing and the communication activity has not developed sufficiently to make any significant assessment of trends and patterns in community use. VirRAD community membership has grown steadily since its launch and at the time of writing has over 350 registered members. Later analyses will also include a qualitative analysis of the nature and content of the various communications, and an exploration of the users' perceptions of the community and the communications occurring therein.

Demographics

The number of registered users has risen fairly steadily during the first three months of community logging. The steep increase in the number of users around day twenty can be attributed to the point at which the community was advertised to the global RadPharm group of about six hundred members. The number of active users (those posting messages during that interval) in the community is usually a good indication of the true community size. This metric peaks at twenty-nine members (12.13 percent of the total membership at that time). This peak in active members corresponded with an introductory task given to members by the

management team in an effort to initiate communications. This can also be seen in measures of relational activity and attributive activity.

Community activity

The activity within the rest of the community (apart from the discussion fora) seems to be steady. The number of events listed has grown to fourteen and the news items are regularly updated. The number of new posts shows peaks soon after community advertisement and after interactive tasks are set.

Relational activity (interactivity)

The length of posts has been fairly constant, at about five hundred characters per message, since logging commenced. The mean thread depth (replies to topics) so far has not strayed from one and the percentage of topics with any replies at all is very low, so there are no indications of information overload so far. The number of topics active in an interval is also affected by the interactive tasks set by the VirRAD management, peaking at 22 topics, around day 20.

Attributive activity (individual activity)

The activity of individuals indicates that a small number of users are currently dominating discussions. Upon closer inspection, this appears to be members of the management team posting messages to stimulate discussions.

CONCLUSIONS

The data obtained to date, both qualitative and quantitative, tends to show that the VirRAD community is regarded as a potentially excellent resource for the radiopharmacy community. It was thought to be usable and useful by focus group participants, although a number of improvements have been suggested by evaluators, as a result of observations, debrief interviews and comments made in the focus group. The results from the separate usability questionnaire were also very positive, only highlighting two points where the community could be improved. However, it must be noted that the sample of twenty-six users responding in this study was small.

The 'ease of use' and 'usefulness' scores for the community, as perceived by users, were very high. Since these constructs have been found to be accurate predictors of future use in other systems (Davis, 1993), we can make assertions that this online community has a high probability of acceptance by its members. This is also supported by members' predictions of their future use of the community, with the majority of users sampled reporting that they would use it regularly. Although the results indicate high acceptance of the community in the future, further studies of actual adoption will be necessary. 'Predicted SOVC' was found to have a close relationship with acceptance and with 'perceived ease of use' and 'perceived usefulness'. Further work should investigate the various aspects of the SOVC construct in the development of other online communities of practice, with use of a larger sample of users, and with the use of a number of qualitative as well as quantitative methods which may better elaborate the existence and nature of causal relationships between these concepts.

The analysis of communication activity within the VirRAD community has shown that although the community membership has been growing steadily since its launch, communications are yet to develop sufficiently to enable assertions to be made about the presence of common ground or other factors known to affect communications in online communities. Small influences have appeared to affect the community; advertisement was identified as having an effect on the number of community members, although the full membership of RadPharm has not yet migrated to VirRAD. The VirRAD management team have been attempting to initiate discussions within the community and have had some influence on communications. A request was made that users post a message in the discussion forums, however, only a small percentage of users complied with this request and, having done so, did not follow up discussions, resulting in a peak in activity, rather than the beginning of some increased interactions. The development patterns of other, similar communities to VirRAD would be useful in comparison to this study, for developing a general model of the development stages of online communities of practice in order to suggest possible ways in which communication activities can be enabled to provide greater community engagement in early development stages.

As noted, this work is part of a broad evaluation programme which continues until February 2005. We shall continue to collect the log data to provide measures of community acceptance and to attempt to determine factors influencing communications when the activity begins to develop. We are also implementing a number of measures including a study to evaluate users' learning effectiveness when using the learning community and a detailed study of users' experiences of being a member of VirRAD, including further investigations into SOVC.

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