Role- and Relationship-based Identity Management for Privacy-enhanced E-learning

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Abstract. An e-learning discussion forum, an essential component of today’s e-learning systems, offers a platform for social learning activities. However, as learners participate in the discussion forum, privacy emerges as a major concern. Privacy concerns in social learning activities originate from one learner’s inability to convey a desired presentation of oneself to another learner. A user-controlled identity management (IM) allows a user to communicate, depending on a context, as much or as little information about the self as they want, and therefore, can provide users desired control over their contextual representations, which in turn contributes to privacy. A role- and relationship-based identity management (RRIM) model provides a coarse-to-fine classification of context based on purpose, role, and relationship. At the coarse level of context, a purpose-based identity allows presentation of oneself for a specific purpose. At the fine level of context, a role-based identity can facilitate presentation of oneself within the capacity of a role, while a relationship-based identity allows a user to reveal or conceal information appropriate for a relationship. We employ the model in a real e-learning system (i.e., iHelp) to facilitate privacy for e-learners in a discussion forum. The results of a pilot study and a large-scale user study in a real course (i.e., Introduction to Sociology) validate that RRIM features help learners maintain their desired level of privacy in an e-learning discussion forum.

Keywords. Privacy, Context, Role-based Identity, Relationship-based Identity, Identity Management, e-Learning

1 INTRODUCTION

An e-learning system needs to support social learning for the Internet generation of learners (in Vassileva (2008)). Constructivist learning theories (e.g., Vygotsky (1978), Wood (1998), Jonassen et al. (1995)) suggest that learners construct their knowledge more effectively through personal experiences and social interaction. According to Brown and Adler (2008), social learning is based on the premise that our understanding of content is socially constructed through conversations about that content and through grounded interactions, especially with others, around problems or actions. To support social learning, e-learning systems offer tools for synchronous and asynchronous interactivity among learners.
Using such tools, learners construct knowledge, make sense of learning, or evaluate their ideas with their peers. Asynchronous communications are generally considered more thoughtful (Hrastinski (2008)) and productive (Chou (2004)) compared to synchronous communication. In this work, we seek to address privacy issues stemming from asynchronous communication that takes place in a discussion forum.

While carrying out learning activities in a discussion forum, users in various roles (e.g., student, marker, instructor, peer-helper, etc.) are expected to present themselves appropriately and act in line with each other’s expectations of privacy. The fact that online learning brings together participants with a wide range of goals, attitudes, and ethical stances, raises concerns of participants who fail to protect their privacy. Moreover, due to lack of physical bodily presence, certain participants may not be as trustworthy and accountable in an e-learning environment as in a traditional classroom. E-learners are becoming more perceptive about the privacy implications of their online activities. Borcea et al. (2006) point out that privacy requirements are obviously important for e-learning, since they establish an unbiased environment without prejudice or favoritism.

As a secondary effect, a privacy-aware e-learning environment can increase awareness of privacy threats as well as understanding of privacy-enhancing mechanisms, since e-learning is intended to transfer knowledge. For example, spyware, known to aid phishing, has been partly responsible for this fraudulent activity and the Webroot survey reveals that 48 percent of teens and young adults have no understanding of phishing 1.

In this paper, privacy is not viewed to be seclusion, rather privacy is treated in light of Goffman’s observation (Goffman (1959)) that individuals selectively reveal and conceal information to present themselves appropriate to social relationships. Inspired by the work of Goffman (1959) and Camenisch et al. (2005), we view identity management as an effective solution to privacy in the social learning context. In a privacy-enhancing identity management scheme, each user participates in a variety of contexts by assuming multiple partial identities and potentially many identifiers or pseudonyms. That is, given a context, some of the participant’s personal information (or misinformation) might be made available to others as the participant’s persona, and that persona would be linked to an identifier or pseudonym.

With the understanding of a context, a person needs to decide on what elements of their identity information to expose to another person so that they can maintain a desired amount of privacy. Therefore, a user’s identity attributes including relevant reputation need to be grouped according to the appropriateness of context. Depending on the context, users decide which information to disclose. For this reason, learners need to be able to differentiate what personal information is to reveal when acting within one role from acting within another role in an e-learning environment.

We implemented role- and relationship-based identity management (RRIM) as a contextual identity management solution to privacy in the e-learning domain. In RRIM, we consider the roles that a user assumes and relationships that a user forges with other users to be fine-grained contexts of their identity (or partial identities). On the other hand, a purpose which maps to a learning activity offers a coarse-grained context of identity. In this approach, a role-based identity hides an actor in the crowd of actors with similar roles (one of many “classmates”), and a relationship-based identity allows an actor to disclose limited information appropriate for a respective relationship (e.g., in my interactions with Alice,

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my pseudonym is Bob, and as Bob, I share my views on religion but not on politics).

In this work, a role- and relationship-based identity management (RRIM) approach of Anwar and Greer (2008) has been implemented in a real e-learning system (i.e., iHelp which is in use at the University of Saskatchewan). The results of a user study in a real course (i.e., Introduction to Sociology) validate that RRIM features help learners maintain their desired level of privacy in an e-learning discussion forum. To validate RRIM, the main research question our study seeks to answer is the following: to what extent does RRIM help e-learners maintain their desired amount of privacy while participating in collaborative learning activities? The analyses of usage data and user survey data show that the system offers the amount of privacy that users seek by providing users with desired control over the choice and disclosure of their identity and contextual awareness of their identities and behaviours. Furthermore, based on the user survey data, the following hypotheses are tested within the context of an e-learning discussion forum: (1) understanding and awareness of contexts contribute to privacy-preserving information sharing, and (2) identity management (awareness and control over identity) contributes to privacy-preserving information sharing.

The rest of the paper is organized as follows. We present related work in Section 2. Section 3 explains the notion of context in the e-learning domain and discusses the process of selecting identity depending on context. In section 4, we present the model for supporting privacy through role- and relationship-based identity in e-learning. Section 5 presents the implementation of RRIM in a course discussion forum within an e-learning environment. Section 6 presents a pilot and a large-scale user study. Section 7 concludes and describes future work.

2 RELATED WORK

Privacy concerns in e-learning Privacy is required for personal autonomy, emotional release, self-evaluation, and limited & protected communications (see Westin (1967)). This is particularly true in the context of e-learning. Eibl (2009) explained problems for confidentiality of personal data in learning management systems (LMS). Klobucar (2006) emphasized on the privacy protection in personalized professional learning settings. Borcea et al. (2006) point out that privacy requirements are obviously important for e-learning, since they establish an unbiased environment. A learner should be able to act under different partial identities or anonymously. The separation of activities encourages learners to be unrestricted and allow them to learn without pressure. E-learning takes place in a collaborative work setting. Privacy in collaborative work settings is important for the purpose of “impression management” (Patil and Kobsa (2003)). We show that in a discussion forum tool, RRIM provides context awareness to help discussants convey desired impressions to each other.

Privacy and context Altman (1975) conceptualizes privacy as a boundary regulation process, where people optimize their accessibility along a spectrum of “openness” and “closedness” depending on a context. According to Dourish and Anderson (2006), flows of information serve as markers of social boundaries, providing a means to negotiate, demonstrate, and sustain patterns of identity, membership, and affiliation in social groups. The goal of privacy is to achieve the desired state along the spectrum of openness and closedness. Therefore, privacy is not simply a matter of avoiding information disclosure,
but rather, context-dependent selective disclosure of personal information. The concerns over privacy seek a necessary balance between privacy and publicity. This balance can be achieved through maintaining the contextual integrity of information. Nissenbaum (2004) observes that information is only sensitive (or not) relative to the context and rules governing the flow of information from one party to another depending on the nature of context. In our work, we attempt to provide contexts of identity using different granularity of context types, and thereby, we try to help users in boundary regulation process for privacy.

**Privacy as relates to identity**  
Goffman’s observations (in Goffman (1959)) that individuals reveal and conceal information selectively to present different versions of the self to different audiences inspired us to think about privacy in terms of identity. Demchak and Fenstermacher (2004) note that privacy is directly related to the knowledge of identity. A similar notion of privacy is manifested in the work of both Samarati (2001) and Sweeney (2002). A general doctrine of their works is to release all the information, but to do so such that the identities of the people who are the subjects of the data (or other sensitive properties found in the data) are protected. This protection of identity is also referred to as anonymity. Applying the the notion of anonymity, Aimeur et al. (2008) proposed a set of protocols to allow learners to provide anonymous credentials throughout the learning process.

When an observer cannot determine the identity model of a user, the user enjoys anonymity. Gavish and Gerdes (1998) categorize three types of anonymity: procedural anonymity (i.e., identity cannot be determined from communication), content-based anonymity (i.e., identity cannot be determined from data content ), and environmental anonymity (i.e., identity cannot be determined by the factors in the environment, e.g., other users) . Our work contributes to procedural anonymity. In collaborative learning, the effect of anonymity on the members’ participations within a group was studied in Cress (2005) and Lea et al. (2001). Our user study is different in that we observed the use of role-based group identity (which offers a degree of anonymity) for the purpose privacy.

**Identity management-based solution to privacy**  
Borcea et al. (2006) and Franz et al. (2006) underscore two aspects of sharing personal data that pertain to privacy protection of learners: (a) Data parsimony - disclose as little personal data as possible, and (b) Data partitioning - partition data into partial identities. The European Future of Identity in the Information Society (FIDIS) project, investigating identity management by Jaquet-Chiffelle et al. (2006), views privacy enhancing identity management as a natural solution to privacy management online. We take the view, similar to Hansen (2008), that a user-controlled identity management system that aims at helping users manage their privacy is a key solution to privacy. In this vein, Anwar and Greer (2008) established a role- and relationship-based identity management (RRIM) model. This paper is an implementation and evaluation of RRIM in e-learning discussion forum.

**Suitability of RRIM**  
In Role based Access Control (popularly known as RBAC- see Barkley et al. (1997)), a subject can access resources based on their assigned roles (conforming to the privileges granted to the respective role). In RRIM, the fundamental assumption is that roles and relationships provide the contexts for articulating identity in a communication episode. Schreck (2003) used RBAC to control
access to user models to enhance privacy and security in user modeling. Since users in e-learning have distinct roles and each role has distinct tasks/interests (For example, Technical administrator, content manager, author, tutor, learner, moderator, anonymous user) (see Borcea et al. (2006)), RRIM is suitable to employ in e-learning domain for privacy.

3 CONTEXT & IDENTITY

3.1 Understanding Context

Privacy is dynamic across individuals, across contexts, and across time. Privacy protects us from being mis-defined and judged out of context (see Cavoukian (2002)). The amount of privacy individuals seek mostly depends on the context in which information is shared. In a context, two partners seeking different amounts of privacy divulge their identities differently; their need for privacy evolves from one interaction to another. For example, we usually seek a maximum amount of privacy with total strangers. However, based on positive experience over further interactions (as trusting relationships grow), we may relax the need for privacy within a relationship.

In this paper, we grapple with privacy issues stemming from social learning activities in online discussion forum. To address privacy with proper identity management, it is imperative that we capture the notion of context. We start by examining how context arises in the e-learning domain. Every learning activity stems from some purpose for its participants. For example, a learner participates in a context of “course question and answer forum” for the purpose of seeking help or offering help. Therefore, purpose is the centrepiece of a context.

Users participate in a learning activity for some purpose. In such a learning activity, users assume roles and forge relationships with one another. While a purpose is used as a means to specify a coarse-grained context, a role or a relationship is considered to define a fine-grained context. We further observe that one purpose cascades into other more fine-grained purposes, attaching a dimension of privacy to the context of identity. The identity acting within the context of a more generic purpose is less privacy sensitive: the more public presentation of the self of a participant. On the other hand, the identity acting within the context of a more specific purpose is more private: the more private presentation of the self of a participant. For example, Fig. 1 shows a user’s involvement in contexts of various purposes, “member of the university community” being the most generic purpose and “registered student providing a course evaluation” being the most specific purpose.

A role empowers an actor to perform a set of activities. At the same time, some activities are expected of a role to perform. For example, an actor in a learner role is expected to be involved in various learning activities, such as attending lectures, participating in a course discussion, taking exams, etc. A relationship involves related entities performing activities together or interacting with each other. Interactions between actors can be heavily influenced by roles. For example, in a learner-teacher relationship, both the learner and the teacher are expected to perform according to their respective roles. The nuances of activities warranted by each role are dictated by individual relationships. For example, two learners seeking help from an instructor are likely going to present themselves somewhat differently, despite the fact that their roles may be identical.
Fig. 1. Based on purpose, a number of contexts in an e-learning domain are shown. In this figure, *University* represents the context with the most generic purpose, while *Evaluation* represents the context with the most specific purpose. Within the *University* context, a user’s participation may be categorized into the *Degree* context, which in turn can further be categorized into a *Course* context and within a *Course* context, a user may participate in *Evaluation* context.
Within a context, participants of different roles form various types of relationships among themselves. Each context – whether specified in terms of purpose, role, or relationship – has temporal dimension. For example, when a student enrolls in a course, their role as a registrant of that course or their relationship with the Teaching Assistant (TA) for the evaluation context ends as the course ends. The notion of a relationship is dynamic as it evolves from one interaction to the next. In other words, roles are predefined as per domain, but relationships are forged as per mutual consents of users. In an e-learning system, participants subscribe to various roles: learners, peer coaches, markers, tutors, and other learning support staff. In various contexts, each participant of an e-learning environment engages in the following types of relationships: one-to-one, one-to-many, many-to-many, and hierarchical.

In a one-to-one relationship, two participants want to be identifiable to each other so that they are distinguishable to each other from other participants. In a one-to-one relationship, the participants share personal information warranted by the role and purpose of the one-to-one relationship. In a one-to-many relationship, a participant wants to present the same version of the self with a group of actors (e.g., discussants in a forum). In a one-to-many relationship, for example, an instructor in a course wants to inform all the course registrants about course materials. A many-to-many relationship can be broken down into two one-to-many relationships: in a student-instructor many-to-many relationship, a student enrolls in multiple courses from different instructors and an instructor teaches different students in multiple courses in a semester. A hierarchical relationship serves to define a hierarchy. For example, a student in a marker role grades other students’ work. An instructor working as a department head supervises other instructors.

The context of identity is an important factor in making a decision of presenting oneself. The context could be specified using purpose, where a specific learning purpose (e.g., to evaluate a student vs. to provide help to a student) is mapped directly to attributes and interactions (e.g., student grades, learning styles, or online interaction) required to support it. Integrating this into an e-learning environment in an unobtrusive yet customizable manner is an important goal of our research towards building a privacy-enhanced learning environment. Therefore, it is important to operationalize “context” for implementing RRIM model. In this section we provide a coarse-to-fine classification of context as relates to identity. Some key aspects of context can be summarized as follows. Let us assume the existence of a set of purposes $P$, a set of users $U$, a set of roles $R$, a set of relationships $ρ$, and a set of contexts $C$. At coarse level, context assignment function $f_c : U \times P \rightarrow C$ assigns users to contexts based on purpose. The context dominance relation, $C H \subseteq C \times C$, captures the notion that each context with a more generic purpose may consist of contexts with more specific purposes. At fine level, the relation, $R A \subseteq C \times R$, assigns a subset of roles to each context and we could regard relationship as a function $f_ρ : R \times R \rightarrow 2^ρ$.

### 3.2 Contextual Identity Model

An identity is a representation of an individual through a dataset that holds information such as attributes (name, student number), traits (biometric information), and preferences (food choices, learning styles) (see Anwar et al. (2006)). A partial identity is a subset of a dataset that represents a complete identity model. The identity dataset which, depending on the application domain, are often published through user profiles. That is, some set of information held in a user profile, labeled with a pseudonym of
some sort represents a partial identity for some individual. Each partial identity can be presented with arbitrarily many different identifiers or pseudonyms. An individual’s behaviour is represented by a set of actions that the individual performs. Records of behaviour (or behaviour summaries such as reputation) may be included in a user profile, and thus can become part of a partial identity.

Fig. 2. A Contextual Identity Model. An entity contains identity and behaviour. An identity consists of attributes, preferences, traits, and reputation, while behaviour is manifested through a set of actions. Reputation is the summary of behaviour. There are a variety of contexts in e-learning domain, each of which serves as a context of partial identity. A partial identity consists of a subset of identity dataset.

When an observer monitors someone’s behaviour with full knowledge of their identity, the actor being monitored is not afforded any privacy. On the other hand, when behaviour is observed while the true identity of the actor being observed is not known (e.g., in the case of anonymous behaviour), the actor being observed enjoys privacy. In the former case, the observer can easily attribute some characteristics to the actual person being observed. In the latter case, the observer can still monitor the behaviour, but it is behaviour of a stranger. Since the observer cannot identify the person being observed, the stranger enjoys a degree of privacy. Therefore, we separate the dataset representing a person into two proper
subsets: identity and behaviour. For example, when Bob is seeking help from Alice, Bob may or may not only know Alice’s true identity. Bob (or others Bob trusts) may have observed Alice’s behaviour with or without knowing her true identity. Even though identity and behaviour are separable, a person’s identity dataset (or partial identity attributes) may include information about reputation earned over the course of their behaviour (cf. Fig. 2).

In line with Altman’s view of privacy as contextual boundary regulation process (see Altman (1975)), our focus in this paper is to help users manage their identity contextually. Now that we have defined context (on page 5), we want to help users construct suitable partial identities depending on contexts. We seek to partition identity along context, which can contribute to desired and limited disclosure which, in turn, contributes to privacy. For example, a graduate student holds multiple partial identities based on their assumed roles – each of which is the context of their identity: a student, a tutor, an instructor, or a marker. In the context of a course in which a student acts in a teaching role, student id number may be extraneous information whereas in the context of a course in which that student acts in a registrant role, their employee id may be irrelevant.

4 ROLE- & RELATIONSHIP-BASED IDENTITY MANAGEMENT

We introduce a purpose-based recursive notion of context for e-learning. For a well-defined purpose, each participant involves in a context by assuming some role and forging some relationships. Each context exists until its underpinning purpose is achieved. As a result, basing solely on the purpose, we define a coarse-grained notion of context. On the other hand, a fine-grained notion of context is defined by means of roles and relationships. As such, any role or relationship is no longer relevant beyond the context it represents. Furthermore, a context may spawn another more granular context, which in turn may spawn yet another context and so on. A context rewinds all its descendant contexts before it comes to an end. Following contextual hierarchy, an identity from a parent context can be used to all of its descendant contexts. For example, in a Computer Science course context, a student may use their role-based identity of type “CS 100 course registrant”, or the student may choose to use identities from progenitor contexts such as that of “computer science major”, from the degree context (i.e., progenitor of the course context), or even more generally, that of “university student”.

In building a role and relationship-based identity management (RRIM) system, we have identified the following tasks: creating roles for different contexts, crafting role-based identities to be used by each participant of a role, allowing each participant to assume multiple roles as they qualify and to switch between roles, facilitating the creation of relationship-based identities between users of different roles to build justifiable relationships, and assigning guarantor privileges to some trusted roles, namely public roles (e.g., a course instructor) to link historical data to their owners to thus make them accountable for their actions. Guarantor privilege authorizes a user to initiate the process of linking historical data to a

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2 In some cases, multiple guarantors may be desirable. As such, separation of duties for guarantors has to be enforced. However, this topic is beyond the scope of our paper.

3 When a discussion thread is no longer live, all the information relating to the postings in that thread becomes historical data. The linking of historical data to owner is necessary for the purpose of assessing the reputation of the posters or the quality of the postings.
user for monitoring bad acting, per se. For linking data to user, it is important to note that even though the system keeps track of the user (e.g., owner of a posting) by their login credentials, a user (except for the guarantor) does not have access to information to link a posting to the true identity of the poster or to link pseudonyms of the posters. Any user who has access to a discussion thread can only read any posting and other relevant information (e.g., the pseudonym of the poster) in that thread. A system implementing RRIM should facilitate the creation of a context for a purpose (e.g., a course context for the offering of a course CS111), roles for various job functions in a context (e.g., a registrant role in the context of Course-CS111), and relationships for various job functions among users of different roles (e.g., a supervisor-supervisee relationship between an instructor and a marker role).

After authentication, the system generates an authorized context hierarchy for a user, in which each context-node corresponds to the affiliation of the user in a context. Once roles are identified (i.e., a set of tasks expected of a role to perform in a given context is grouped under a role name), a role-based identity creation involves assigning a user to a pertinent role, generating a default role-based pseudonym for the user on the assumption of a role, and creating an identity dataset consisting of information pertinent to the role. Based on their assumed role within a context, the system should allow a user to choose an appropriate relationship with another user, help a user create a relationship-based identity dataset, and generate a relationship-based pseudonym to be used in a relationship. For providing awareness cues to a user, the system should display the context hierarchy relevant to them together with their assumed roles and relationships therein.

Even though a role-based identity from one context can be used to all the descendant contexts, a relationship-based identity in one context is irrelevant in another context. For example, instead of using her pseudonym for registrant role in a course context, CS111registrant43, a student may choose to appear as cs37, revealing her affiliation to the Computer Science department context without showing affiliation with a specific course. Other enrollees of that course would not know whether cs37 is a co-registrant in the respective course, an instructor of this course, or a student in the department who may or may not be enrolled in that course. When cs37 seeks technical writing help from the learning centre and creates a relationship-based identity with a writing help tutor, she may choose to reveal more personal information - perhaps selecting a pseudonym like Alice. Due to the temporal dimension of role or relationship, any information released under a role or relationship ought to be virtually unusable for the counterpart when the respective role or relationship expires. Anytime, a participant fears a privacy threat in a relationship-based identity, the participant may stop using that relationship-based identity and take refuge in their role-based identity. The participant can negotiate a new relationship at any time and craft a new relationship-based identity.

Ideally, a relationship-based identity is constrained by the purpose of a relationship, which in turn is constrained by the roles of the participants involved in that relationship. A relationship-based identity should not be inferable from another. Users can create and abandon relationship-based entities at any time. Since all the participants in the same role carry a default role-based identity, the role-based identity approach provides a degree of anonymity to the participants of a role.

Illustrated in Table 1 are the types of identities available in RRIM. Suppose RRIM is deployed in the “question and answer forum” of a course CS111. As an individual (when an individual identity, as opposed to a group identity, is used), the discussant is distinguishable from other participants. As a
group member (when a group identity is used), the discussant is indistinguishable from other members of his group. Using a group identity for a context, a discussant conveys her affiliation to the context to other discussants. Using a group identity for a role, which is a finer grained representation of context, the discussant conveys to other discussants that he is one of the many actors who function in a particular role, say a tutor (e.g., a-Tutor-for-CS111) who helps learners of CS111. Based on the purpose, a coarse-grained context or a fine-grained context such as a role can serve as the context of a group or an individual identity. Instead of using multiple partial identities, a person may also choose to use one identity across contexts, namely a user-level identity. A relationship-based identity is an individual identity whose context is a relationship.

Table 1

In this identity table, we show different types of partial identities: across context, purpose-based, role-based, and relationship-based. In one dimension, we present the contextual basis of these identities, and on the other dimension, we consider individual and group representations of the partial identities.

<table>
<thead>
<tr>
<th>Context</th>
<th>Group Representation</th>
<th>Individual Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Across contexts</td>
<td></td>
<td>User-level Identity</td>
</tr>
<tr>
<td>Purpose</td>
<td>Purpose-based Identity</td>
<td>Purpose-based Identity</td>
</tr>
<tr>
<td>Role</td>
<td>Role-based Identity</td>
<td></td>
</tr>
<tr>
<td>Relationship</td>
<td></td>
<td>Relationship-based Identity</td>
</tr>
</tbody>
</table>

The creation and maintenance of so many role- and relationship-based identities may seem like daunting tasks for users. However, in an e-learning environment, contexts, roles, and relationships are relatively predictable and well-defined. In our implementation, described in the next section, context and role assignments providing a default role-based identity for each role that the user is entitled are automatically generated. The system also enables users to engage in likely relationships (determined by their assumed roles in respective contexts) and provides relationship-based identities. To help users manage their identities, the system provides awareness to users through visualization of contexts, roles, relationships and associated pseudonyms of users.

5 IMPLEMENTATION

We have implemented RRIM in iHelp Discussions, a component tool of the iHelp Online Learning System. In this work, iHelp Discussions system is treated as a trusted entity, and therefore, it stores all the information of an authenticated user. The privacy needs of users arise from their desires to present themselves differently among each other. We do not consider any privacy threat from the system.

System Operation. The iHelp Discussions tool serves as a virtual meeting place for students, markers, tutorial assistants, instructors, guests, etc. in a university course. The iHelp Discussions system has enjoyed relatively wide use throughout the Computer Science curriculum at the University of Saskatchewan. This system integrates with the existing academic role structure in courses to seamlessly support the various kinds of users (students, markers, tutorial assistants, volunteer helpers, instructors,
etc.) and the permissions and needs that they have with their courses. Postings fall into categories specified by the instructor (e.g., Midterm, Module1, etc.). It facilitates context separation by providing context specific interaction categories. For example, the iHelp Discussion category under the heading of “CS-350-Assignment-1” would be open only to students in CS 350 course as well as the instructor, teaching assistants, and other potential helpers. Learners post and respond, seeking help and offering help, and instructors can do the same. In summary, iHelp Discussions tool provides supports for following three objectives to be achieved in an online learning environment: (1) allow learners to construct knowledge through exchange of personal experience and social interaction, (2) seek help from and offer help to other members of a learning community, (3) allow instructors and tutorial assistants to provide reinforcement and pedagogical intervention to learning.

Previously, in the iHelp Discussions System, participants had the option of posting either anonymously, or using their real name (i.e., first initial followed by last name), or using a self-created alias. In implementing the RRIM model in iHelp, various features are added to iHelp Discussions in order to help participants manage their contextual partial identities to enhance privacy. The added RRIM features of iHelp Discussions are implemented in Java, JSP, JavaScript, DHTML, HTML, and XML that use a MySQL database at the backend. The implementation makes extensive use of asynchronous JavaScript (i.e., AJAX) and DHTML to realize the interactive markup effects. In the implementation, the system plays the role of a facilitator of identity and reputation. Henceforth, we refer to our implementation as iHelp Discussions with RRIM. We could categorize all the features of iHelp Discussions with RRIM into 2 categories: context creation & awareness (Fig. 3), identity creation & management (Fig. 4).

We expect that different configurations of RRIM are possible based on different pedagogical purposes. In a coarse-grained solely purpose-based abstraction of context, all the participants may play just one role - their affiliation to a context (e.g., all discussants share personal experiences on a particular issue). In that case, the role does not offer a fine-grained categorization of context of an identity. Sometimes, the same set of roles may be appropriate across contexts (e.g., addressing multiple social issues from the perspectives of a set of social roles). In the pilot study (see on page 17), we formulate a configuration where discussants are allowed to participate within context using role- and relationship-based identity and between-contexts using purpose-based identity. Each context offers a different set of roles to its participants.

In the large-scale study (see on page 17), iHelp Discussions with RRIM provides the online discussion component (see Fig. 6) of Introduction to Sociology course. The main pedagogical objective of the discussion component in this course aligns with the first objective of iHelp Discussions: allow learners to construct knowledge through exchange of personal experiences and social interactions. Specifically, students in this course were expected to seek answers to questions on controversial topics of social interest so as to co-construct explanations. The system provides a context for the purpose of discussing each controversial topic, addressing a social or behavioural question chosen by the instructor of the course. As per specifications of the course instructor, the system assigns a set of roles for students to participate across contexts. Since there are no hierarchical relationships among these topics, an identity at the granularity of purpose (i.e., a partial identity that highlights contextual affiliation) is considered redundant. As a result, the version of the system in the large-scale study does not offer identity creation at the (coarse)
Fig. 3. A tree view of contexts based on purposes and roles (the upper left pane of the main Window of iHelp Discussions with RRIM (screenshot from pilot study). Note that, in this figure, categories are purpose-based abstraction of context and roles define fine-grained notion of context.
### Current aliases:

<table>
<thead>
<tr>
<th>Category</th>
<th>Alias</th>
</tr>
</thead>
<tbody>
<tr>
<td>User-level Aliases</td>
<td>M Anwar (moa060)</td>
</tr>
<tr>
<td></td>
<td>(default)</td>
</tr>
<tr>
<td></td>
<td>abc</td>
</tr>
<tr>
<td></td>
<td>dont care</td>
</tr>
<tr>
<td>Apathetic</td>
<td>Apathetic#</td>
</tr>
<tr>
<td></td>
<td>CareFree</td>
</tr>
<tr>
<td></td>
<td>Yo</td>
</tr>
<tr>
<td>DeepThinkerIntellectual</td>
<td>Intellectual#</td>
</tr>
<tr>
<td></td>
<td>Sage</td>
</tr>
<tr>
<td>DevilsAdvocate</td>
<td>Devil#</td>
</tr>
<tr>
<td></td>
<td>asd</td>
</tr>
<tr>
<td>Environmentalist&amp;Activist</td>
<td>Activist#</td>
</tr>
<tr>
<td></td>
<td>Suzuki</td>
</tr>
<tr>
<td>Luddite</td>
<td>Luddite#</td>
</tr>
<tr>
<td>MisCongeniality</td>
<td>Congeniality#</td>
</tr>
<tr>
<td>RightwingConservative</td>
<td>Conservative#</td>
</tr>
<tr>
<td></td>
<td>Bush</td>
</tr>
<tr>
<td>Sexist</td>
<td>Sexist#</td>
</tr>
<tr>
<td></td>
<td>Hotty</td>
</tr>
<tr>
<td></td>
<td>Man</td>
</tr>
</tbody>
</table>

### Actions:
- Create new alias

---

Fig.4. A list of three categories of pseudonyms (aliases) for partial identities of three categories: user-level (e.g., M Anwar), role-based (e.g., Apathetic#), and relationship-based (e.g., CareFree). On the category column (left), identity categories (i.e., user-level or different roles) are listed, while on the alias column (right) pseudonyms are listed. Pseudonym ending in '#' is a role-based pseudonym. This screenshot is taken from iHelp Discussions with RRIM (large-scale study).
granularity of purpose-based context.

5.1 Context Creation

In iHelp Discussions with RRIM, the system presents all the potential topics of discussion (as categories of discussion), each of which later used as a coarse-grained context of identity. The system also provides potential roles that can be associated with each of the categories. The provision of categories and roles are done as per specifications of the course instructor. The system assigns appropriate roles to each category and assigns fitting roles to each user so that each user may participate in a communicative context representing various perspectives of their intended role(s). The participatory contexts and roles of each user are organized hierarchically and presented persistently at the left pane of the discussion window as a tree view (see upper left pane in Fig. 6). For posting a new message or replying to a message (see Fig. 7), each user is presented with all the possible purposes and roles of their participation.

Fig.5. Message List: The upper right pane of the main window of iHelp Discussions with RRIM (screenshot from large-scale study). Under subject heading, the subjects of posts are specified. The partial identities (pseudonyms) of participants are specified under poster heading. The "[me]" marker next to poster’s pseudonym helps users identify their postings even when they post message anonymously. Following a pseudonym, there appears a role name to remind the user about their assumed role.

5.2 Identity Creation and Management

A discussant can have three types of pseudonyms to represent their three types of partial identities respectively: user-level, role-bases, and relationship-based. Based on their group memberships, group identities (e.g., a role-based identity - a group of users activating a role) are created for discussants by the system. The system provides user interface facilities for creating individual partial identities, such as a relationship-based partial identity. The system also provides a default user-level identity based on the true identity of a discussant. The system allows discussants to create as many user-level partial identities as

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4Recall that our model also provides purpose-based identity. However, based on the pedagogical objectives of the discussion for the Introduction to Sociology course, the instructor chooses not to use purpose-based identities.
they like. However, each pseudonym that a user creates to represent themselves as individuals (i.e., user-level or relationship-based identities) has to be unique and the system checks for whether that pseudonym already exists before approval.

When seeking more openness (for recognition or publicity), a discussant may use a user-level identity across multiple contexts. For example, BobTheDiscussant pseudonym, when used across multiple contexts to represent a user-level identity, allows a participant to be identified across these contexts or sub-contexts. Articulating a relationship, two discussants may use a relationship-based identity to communicate with one another. For example, two discussants may communicate with one another as BobTheHelper and MaryTheHelpee to maintain a helper-helpee relationship.

Both the purpose-based and role-based identities are represented by a group pseudonym. Based on the purpose and role of participation, each participant is provided with pseudonyms to represent their different purpose- and role-based group identities. To allow user easy distinction, a group pseudonym ends with a #. In the Fig. 3, ABR# is a purpose-based group pseudonym, which makes a discussant indistinguishable from other discussants in the discussion context of Abortion. It also provides the discussant a group identity. On the other hand, Opponent# is a role-based identity representing the discussant as a member of the group of individuals taking the Abortion − Opponent role. The main difference between purpose and role is the granularity of context that each concept represents. As a coarse notion of context, purpose is used to create a partial identity. However, a user may articulate her role during participation as a more finer notion of context in order to choose a partial identity.

In replying or posting new messages, discussants are presented with a list of their pseudonyms to choose from, representing all the pertinent partial identities under a given context (Shown in Fig. 7 from large-scale study). For each posting or reply, the discussant is expected to select a suitable role- or relationship-based partial identity. Each posting carries the discussant’s “role name” to help the readers of the posting understand the context of the posting. To help discussants identify their own postings, even when group identities are used, each of their own posting carries a (me) marker next to the poster’s pseudonym. When a role-based identity is used, the “role name” followed by a (me) marker is attached next to the poster’s pseudonym to make the poster aware of the “role” they assumed in posting a particular message (Shown in Fig. 5). As a result, the awareness cues help participants participate according to the contexts of their identities in their postings through awareness of which posting they made themselves and which postings came from others. The context of identity helps learners articulate their participation and disclosure in the discussion forum so as to maintain their desired level of privacy.

6 USER STUDY

The RRIM model was implemented as an extension to the existing iHelp Discussions tool, an online discussion forum in use at the University of Saskatchewan as part of iHelp e-learning system. The evaluation of the implemented RRIM features was conducted in a pilot and a large-scale user study. The study was approved by the local Committee on Ethics in Behavioural Sciences Research. In the study, the following hypotheses are tested (in the context of e-learning discussion forum) through analyzing usage data and user survey and interview data: (a) understanding and awareness of context contributes to privacy-preserving information sharing, (b) role- and relationship-based Identity management supports
privacy-preserving information sharing.

6.1 Pilot Study

6.1.1 Methodology

In the pilot study (see Anwar and Greer (2009)), the system was initialized to generate seven different discussion contexts for potential controversial topics: a. Same-sex Marriage, b. Abortion, c. Tibet Issues, d. Mission in Afghanistan, e. Collaboration vs. Plagiarism, f. Schools Kill Creativity, and g. Net Neutrality. Five (volunteer) participants used our system for over a two week period, making 112 substantive postings in these seven different contexts. The participants were Computer Science graduate students who were trained to use the system in a one-on-one session. Four of the participants were male while one was female. Here are some of the suggested roles for the discussants of some contexts:

- Same-sex Marriage: Proponent, Opponent, and Gay/Lesbian
- Abortion: Mother, Doctor, Religious Leader, Proponent, and Opponent
- Schools Kill Creativity: Student, School Administrator, Professor, Proponent, and Opponent

While discussing controversial issues, many people fear being embarrassed, looking foolish, or not being accepted. One of our contentions is that role- and relationship-based identity management effectively supports self-reflection types of activities, one of the reasons why privacy is so desirable (Westin (1967)). All of the participants chose more than one, sometimes even quite opposite, roles on a given issue substantiating our contention.

6.1.2 Results

The average number of postings made using the three different identity types are the followings: user-level = 1.17 per participant, role-based = 10.5 per participant, and purpose-based = 7 per participant. The participants rarely used their user-level identity, which is ideal for publicity. The participants could not correctly guess the number of different actual people who participated in the discussion. All the participants reported that they could rarely identify which postings belonged to which actual users. This is an indication that role-based and purpose-based identities effectively hide user-level identities.

This study was mostly an exploratory study on evaluating the usability of iHelp Discussions with RRIM. In this study, our aim was to use the system to offer a safe discussion forum to discuss controversial issues in an e-learning setting. Furthermore, here we formulate a configuration of RRIM where purpose-based identities are relevant, and each purpose offers a different set of roles to its participants.

6.2 Large scale Study

6.2.1 Methodology

In the large-scale study, the system was used to support online course discussions of 35 students and an instructor in an intensive six-week undergraduate course on Introduction to Sociology. The study was
done in 2 phases (each phase runs for 3 weeks): (1) In the first three-week period, the class made 173 postings using the original version of iHelp Discussions (without RRIM), and (2) In the next three week period, they made 302 postings using a version of iHelp Discussions with RRIM features. In each phase, the participants (students and the instructor) discussed topics under eleven contexts, each addressing eleven different social and behavioural questions. Prior to each phase of the study, users were trained to use the system. At the end of the second phase, 25 participants (of the 35 who used the system) took a post-use online survey to share their use experience and their attitudes towards privacy.

Throughout the course, the participants used iHelp Discussions to explore and co-construct answers to 22 questions, 11 questions in phase 1 and 11 questions in phase 2, using their personal experience and sociological knowledge. These questions are chosen by the instructor of the course as per the course objectives. In the first phase (first 3 weeks), students used the original iHelp Discussions, which required them to use their public identities (i.e., first initial followed by last name) to post a new message or to reply to a posting. For the phase 2 (next 3 weeks), discussants used the iHelp Discussions with RRIM, which allowed them to create multiple role- and relationship-based identities, provided awareness support for contexts and identities, and enabled them to rate others and query others’ ratings as well as monitor their own identity-specific reputation (ratings others assigned to them). The following eight roles were suggested by the instructor (and offered in the system) for the discussants (to take on) to shed perspectives of respective roles on different contexts: Devil’s Advocate, Right-wing Conservative, Environmentalist/Activist, Sexist, Apathetic, Deep thinker/Intellectual, Luddite, Miss Congeniality. In summary, across the 2 study phases, the system offered three identity choices:

1. True identity. No privacy where learners are identified. It is the default option and presented by their real name.

2. Complete Anonymity, where learners can answer the questions without disclosing any identity information with the alias “anonymous”.

3. RRIM supported coarse-grained (purpose-based) and fine-grained (role- and relationship-based) contextual identities (see Fig. 4), where learners can answer the questions of their course assignment using RRIM offered contextual identities.

In phase 2, in addition to the true identity, the system offered three types of pseudonyms to each participant: (i) a user-level pseudonym type to represent a discussant across contexts, e.g., Sam23, (ii) a role-based group identity type for each role within a context, representing the group of discussants, participating in a given role in a given context, e.g., “a Devil’s Advocate”, and (iii) a relationship-based individual identity type for each role within a context, representing an individual participating in a given role in a given context, e.g., “Fred the Sexist”. Since there is no hierarchical relationship among purposes presented in the phase 2, the purpose-based pseudonym is omitted in this study.
Table 2
User survey response (large-scale study). This table shows users’ levels of agreement to likert items as a measurement of privacy satisfaction in our privacy-enhanced version of iHelp Discussions forum.

<table>
<thead>
<tr>
<th>Item</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfied with Overall Privacy</td>
<td>36%</td>
<td>40%</td>
<td>24%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>In-obtrusive</td>
<td>36%</td>
<td>12%</td>
<td>44%</td>
<td>0%</td>
<td>8%</td>
</tr>
<tr>
<td>Satisfied with Privacy-preserving Info Sharing</td>
<td>44%</td>
<td>32%</td>
<td>24%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Felt in Control of Identity Choices</td>
<td>36%</td>
<td>40%</td>
<td>20%</td>
<td>4%</td>
<td>0%</td>
</tr>
<tr>
<td>Satisfied with Identity Disclosure</td>
<td>36%</td>
<td>24%</td>
<td>36%</td>
<td>4%</td>
<td>0%</td>
</tr>
<tr>
<td>Act More Candidly Using Partial Identities</td>
<td>16%</td>
<td>36%</td>
<td>44%</td>
<td>4%</td>
<td>0%</td>
</tr>
<tr>
<td>Found the System easy-to-use</td>
<td>40%</td>
<td>20%</td>
<td>28%</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>Found the System easy-to-learn</td>
<td>36%</td>
<td>16%</td>
<td>36%</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>System Helped Me Maintain Privacy</td>
<td>32%</td>
<td>40%</td>
<td>20%</td>
<td>8%</td>
<td>0%</td>
</tr>
<tr>
<td>Helped Me Communicate Appropriately in Context</td>
<td>36%</td>
<td>32%</td>
<td>32%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Helped Me to Safely Disclose Info</td>
<td>40%</td>
<td>28%</td>
<td>32%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Helped Me to be Aware of Context</td>
<td>24%</td>
<td>28%</td>
<td>48%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Helped Me to be Aware of my Assumed Identity</td>
<td>24%</td>
<td>28%</td>
<td>44%</td>
<td>4%</td>
<td>0%</td>
</tr>
<tr>
<td>Able to Separate my Postings from Others</td>
<td>32%</td>
<td>32%</td>
<td>28%</td>
<td>0%</td>
<td>8%</td>
</tr>
<tr>
<td>Aware of Expected Behaviour of Assumed Identity</td>
<td>36%</td>
<td>28%</td>
<td>24%</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>Able to Link Postings</td>
<td>8%</td>
<td>28%</td>
<td>36%</td>
<td>16%</td>
<td>12%</td>
</tr>
<tr>
<td>More Authentic in Privacy-augmented iHelp</td>
<td>28%</td>
<td>16%</td>
<td>44%</td>
<td>12%</td>
<td>0%</td>
</tr>
<tr>
<td>More Direct in Privacy-augmented iHelp</td>
<td>32%</td>
<td>28%</td>
<td>32%</td>
<td>8%</td>
<td>0%</td>
</tr>
<tr>
<td>Used Group Identity to Rant</td>
<td>24%</td>
<td>20%</td>
<td>40%</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>Intentionally Provocative because of Identity Choices</td>
<td>28%</td>
<td>20%</td>
<td>44%</td>
<td>4%</td>
<td>4%</td>
</tr>
</tbody>
</table>

6.2.2 Results

After the iHelp Discussions with RRIM was introduced, participants made 4% of their postings anonymously, 36% of postings using their true identities, and 59% of postings using role-based and relationship-based identities. Within role-based and relationship-based identities, 22% of postings are made using role-based group identities (e.g., Devil# for Devil’s Advocate role), where as 37% of postings are made using relationship-based identities. 1% postings are made using user-level identities. A significant use of role-based and relationship-based identities underlines the significance of role- and relationship-based identity management and appropriateness of operationalizing fine-grained context in terms of roles and relationships.

The participants of this study had a chance to compare the original version of iHelp with the iHelp Discussions with RRIM. The following item from the survey is an example where the survey-takers are asked to compare their use experience of the two versions: *The system enabled me to act more candidly using my partial identities (in version 2) than I would have done using a single “real identity” (in version 1).* On this item 52% of the survey takers agreed, while 4% of them disagreed. Table 2 reports survey responses as percentages (relative frequencies) of agreement and disagreement across different likert items.

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5 Anonymous postings are anonymous to other participants, but the participants had to login to the system prior to participation. Therefore the system can count postings including the anonymous ones for each participant.
An analysis of usage data indicates about 75% increase in participation from the original version of iHelp. Table 3 shows significantly higher participation (t-stat = 2.11 and p < 0.05) in iHelp Discussions with RRIM version (Mean = 8.4) than original iHelp version (Mean = 4.8). As we know that all learners do not participate equally in a discussion, we see a high standard deviation in participation for both the original and the RRIM versions of iHelp Discussions. Moreover, privacy does not equally matter to everybody. Those who cared for privacy and felt safe participated much more than others.

Anecdotal accounts by the students and observations from the instructor also suggest that the privacy features greatly increased participation. Following are some remarks from the students and the course instructor:

“We are more comfortable participating in the 2nd version (RRIM) than participating in the 1st (original) version.”

The course instructor commented, “The quality of participation has improved in the 2nd version (iHelp Discussions with RRIM). More open, more fun.”

“Very good idea, allows for discussion outside of class. Hope to see it utilized in other classes.”

“I found that I had to read the same postings more than once because there were different ways (different identity choices) to reply to the questions (comments).”

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Participation comparison in large-scale study. This table compares participation between the original iHelp Discussions and iHelp Discussions with RRIM. A significantly higher participation is observed in the paired t-test.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Original) iHelp Discussions</td>
</tr>
<tr>
<td>mean posting/participant</td>
<td>4.8</td>
</tr>
<tr>
<td>variance</td>
<td>21.9</td>
</tr>
<tr>
<td>df</td>
<td>35</td>
</tr>
<tr>
<td>t Stat</td>
<td>2.1</td>
</tr>
<tr>
<td>p-value</td>
<td>0.04</td>
</tr>
</tbody>
</table>

The survey indicates that those who perceived that their privacy was maintained were more direct and authentic in their communication. Some of the participants who were satisfied with their privacy also experienced emotional release using their multiple partial identities. Further analyses of the survey data of Table 2 confirm our hypotheses about the relationships between privacy and each of context and identity.

**Hypothesis 1:** Understanding and awareness of contexts contribute to privacy-preserving information sharing.

To test hypothesis 1, the survey takers’ levels of privacy satisfaction are considered dependent variables. This is compared against their agreement in the following two independent variables: (1) the system helped them communicate appropriately in a context, and (2) the system helped them to be aware of the context of a communicative episode. Thus we tried to predict levels of privacy satisfaction from understanding and awareness of context. We see in Table 4 that the understanding and awareness of context contribute to privacy satisfaction.
Table 4
This table shows the results from multiple regression on the prediction of privacy satisfaction (dependent variable) from users’ satisfaction in the system’s offered features on context understanding and context awareness (independent variables). Results demonstrate that the understanding and awareness of context contributes to privacy.

<table>
<thead>
<tr>
<th>Dependent</th>
<th>Independent</th>
<th>Coefficient ($\beta$)</th>
<th>$R$-square</th>
<th>t</th>
<th>p (acceptable &lt; .05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Privacy Satisfaction</td>
<td>Appropriate Contextual Communication</td>
<td>.48</td>
<td>.54</td>
<td>2.6</td>
<td>.016</td>
</tr>
<tr>
<td></td>
<td>Awareness of Context</td>
<td>.47</td>
<td></td>
<td>2.52</td>
<td>.019</td>
</tr>
</tbody>
</table>

The impacts of appropriate contextual communication and context awareness on privacy satisfaction are statistically significant ($t = 2.6$ and $t = 2.5$ respectively). Those who experience appropriate contextual communication also are satisfied with their privacy ($\beta = .48$, $p = .016$). Those who have greater awareness of context also are more satisfied with privacy ($\beta = .47$, $p = .019$). The $R$-square indicates that 54% of the variation in the users’ level of privacy satisfaction is explained by the set of independent variables representing their understanding and awareness of context. Therefore, we can conclude that results from multiple regression in Table 4 confirm our hypothesis that the system provides adequate understanding and awareness of context contributing to privacy-preserving information sharing.

Hypothesis 2: Identity management (awareness and control over identity) contributes to privacy-preserving information sharing.

To test hypothesis 2, the survey takers’ levels of privacy satisfaction are considered dependent variables. This is compared against their agreement in the following three independent variables: (1) they felt in control of their identity choices, (2) they were satisfied with the way the system enabled them to manage how they disclosed their identities, and (3) the system enabled them to act more candidly using their partial identities. Thus we tried to predict levels of privacy satisfaction from users’ satisfaction in the system’s offered identity management features. We see in Table 5 that awareness and control over identity contribute to privacy satisfaction.

Table 5
This table shows multiple regression analysis with privacy satisfaction as the dependent variable and users’ satisfaction in the values offered from identity management features (i.e., identity choices, disclosure control, ability to act candidly) as independent variables. The results confirm that Identity Management contributes to privacy.

<table>
<thead>
<tr>
<th>Dependent</th>
<th>Independent</th>
<th>Coefficient ($\beta$)</th>
<th>$R$-square</th>
<th>t</th>
<th>p (acceptable &lt; .05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Privacy Satisfaction</td>
<td>Control of Identity Choices</td>
<td>.69</td>
<td>.67</td>
<td>3.2</td>
<td>.004</td>
</tr>
<tr>
<td></td>
<td>Manage Disclosure of Identity</td>
<td>.15</td>
<td></td>
<td>.81</td>
<td>.43</td>
</tr>
<tr>
<td></td>
<td>Act candidly using partial identity</td>
<td>.23</td>
<td></td>
<td>1.6</td>
<td>.12</td>
</tr>
</tbody>
</table>

The control over identity choices has statistically significant impact on privacy satisfaction. Those who experience control of identity choices are also very satisfied with their privacy ($\beta = .69$, $p = .004$). Those who act candidly using partial identity may be weakly satisfied with their privacy ($\beta = .23$, $p = .12$). However, those who managed disclosure of identity are not significantly satisfied with privacy ($\beta = .15$, $p = .43$). The $R - square$ indicates that 67% of the variation in the users’ level of privacy satisfaction
is explained by the set of independent variables representing their satisfaction in identity management features.

Therefore, we can conclude that results from multiple regression in Table 5 confirm our hypothesis that the system provides adequate identity management support contributing to privacy-preserving information sharing.

7 CONCLUSION & FUTURE WORK

The privacy solution provided by our proposed role- and relationship-based identity management is two-fold: on one hand, our solution helps users construct contextual identity based on the purpose, role, and relationship. On the other hand, privacy vulnerability from disclosed information is minimized by the following features: choice of switching among partial identities, temporal aspect of role and relationship, expiration of context, and disclosure management through awareness.

An implementation of the role- and relationship-based identity management in the discussion tool of the iHelp e-learning environment was studied. A study was conducted in a course with 35 students and an instructor (25 of them participated in the survey) in a sociology course. These were consistent and reliable evidence, through the survey and usage data, that the system offered learners a satisfactory-level of privacy while allowing them to exchange their views (sharing information). Analyses of survey data confirm the following two hypotheses within the context of a discussion forum: (a) Understanding and awareness of context offered by privacy-augmented iHelp contribute to privacy-preserving information sharing (b) Identity management (awareness and control over identity) offered by privacy-augmented iHelp contributes to privacy-preserving information sharing. We plan to conduct further studies to test whether these hypotheses are also true in other communication platforms.

The survey data also indicate that a significant portion of the participants were more direct and authentic in expressing their views in privacy-augmented version of iHelp than the original version without RRIM. Overall, the participants reported enjoying the privacy-augmented version more than the original version of iHelp. The participants of the studies found privacy-augmented iHelp to be a privacy-preserving information sharing tool. Specifically, statistical analyses of usage and survey data confirm the role of context and identity in preserving privacy. RRIM delivers privacy by contextualizing (associating each identity with a context) identity by means of role- and relationship-based identity management. This research provides (in both the user studies) communication episodes and contexts that are rather controversial (high risk) in nature, and therefore, where privacy becomes more important.

We understand that the notion of context in other application areas like social networks are not so structured and rather dynamic. Our future work would involve operationalizing contexts in such domains so as to develop privacy enhancing identity management solution for such domains. In addition to that, we plan to perform more experiments to see whether the validated hypotheses in our study can be more generalized for other application domains.

REFERENCES


Fig. 6. The main Window of iHelp Discussions with RRIM (screenshot from large-scale study). The top-left of the window displays contexts and roles of participation for a user. In the bottom-left of the window, the link “Aliases” allows a user to construct partial identities. The top-right of the window displays the subject, replies count, poster’s pseudonym representing partial identity types, and date and time of each posting. To help differentiate own postings from others, when a posting using a role-based pseudonym or anonymous posting is made, “(me)” tag is attached.
Anwar and Greer / Role- and Relationship-based Identity Management

Fig. 7. Reply Window of iHelp Discussion with RRIM (screenshot from large-scale study). To reply a post, a user has to choose an appropriate partial identity (from a list of user-level, role-based, and relationship-based partial identities) by choosing its pseudonym. For example, "Apathetic", "Carefree", and "Patriotic" are pseudonyms for user-level, role-based, and relationship-based partial identities respectively.

To reply a post, a user has to choose an appropriate partial identity (from a list of user-level, role-based, and relationship-based partial identities) by choosing its pseudonym. For example, "Apathetic", "Carefree", and "Patriotic" are pseudonyms for user-level, role-based, and relationship-based partial identities respectively.