Exploring Trust in Personal Learning Environments

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***Abstract*—The design of effective trust and reputation mechanisms for personal learning environments (PLEs) is believed to be a promising research direction. In this paper, we propose a 4-dimensional trust model that complies with the specific requirements of PLEs. Trust is explored in four dimensions: trustor, trustee, context and visibility. The importance of these four dimensions is investigated through a number of scenarios. The model is implemented in a PLE platform named Graaasp. Preliminary evaluation of usefulness is conducted through a user study and some interesting findings are discussed in the end.**

Keywords-trust; reputation; personal learning environment; rating; ranking

I. INTRODUCTION

Benefiting from the success of Web 2.0 social media, interactive information sharing has become pervasive. For users surrounded by an abundance of information, the challenge now is how to determine which resources can be relied upon and who is reliable enough to interact with. To solve this problem, a number of trust and reputation systems have been developed in various platforms, including e-commercial sites, product review systems, and professional communities. Trust and reputation measures can help users decide whether or not to interact with a given party in the future, or whether it is safe to depend on a given resource [1]. This creates an incentive for good behavior, therefore inducing a positive effect on the quality of interaction in online communities.

As a particular support framework for interaction in online communities, personal learning environments (PLEs) embed tools, services, content and people involved in the digital part of the learning process [2] [3]. Web 2.0 functionalities like blogging, tagging, rating and commenting are gradually incorporated into learners' overall learning ecology, contributing to increasing learning incentives and enhancing the learning experience [4]. On one hand, these Web 2.0 features enable learners to express opinions easily and facilitate accumulating domain knowledge. On the other hand, learners' active contributions produce a large amount of user-generated content, which may lead to information overflow. In such an open learning environment, it is not easy for learners to find suitable people to learn from or collaborate with. Moreover, the flood of data might bring about the challenge of selecting useful learning resources depending on personal learning goals. Therefore, research efforts are needed to design appropriate trust and reputation mechanisms for PLEs, aiming at expertise assessment and quality assurance to support self-directed learning activities.

As a complex social concept, trust reflects the subjective perception one party holds about another party. It's asymmetrical, transferable, dynamic, and context-dependent, and can be influenced by various factors. Trust has been interpreted in different ways to comply with specific requirements of various domains. In this paper, a usable trust model for personal learning environments is investigated and implemented in a PLE prototype named *Graaap* [1]. Preliminary evaluation of usefulness has been conducted through a user study. The rest of this paper is organized as follows. Section II introduces the existing trust and reputation schemes, and discusses the specific aspects of PLEs that call for different trust and reputation models. A trust model dedicated to PLEs is proposed in Section III. Section IV introduces the *Graaasp* prototype and illustrates the implementation of the proposed trust model in it. User evaluation and main findings are addressed afterwards in Section V. Finally, Section VI concludes the paper and discusses the future work.

II. RELATED WORK

In order to develop effective trust and reputation mechanisms, a number of attempts have been made in both literature and practice. The simplest but most widely used scheme is to compute an average or summary of all ratings for an entity. The reputation systems used by eBay [2], Epinions[3] and Amazon[4] fall into this category. However, this scheme is primitive and therefore gives a poor picture on an entity's reputation score [5].

Google's PageRank [6], Advogato's reputation scheme [7], and EigenTrust model [8] can be categorized as flow models, where trust or reputation is computed by transitive iteration through looped or arbitrarily long chains. In short, a participant's trust or reputation score increases as a function of incoming flow, and decreases as a function of outgoing flow. Flow model-based schemes adopt global trust metrics, where a single trust or reputation score is associated with each participant and displayed to all members in the community.

Some researchers have proposed to use mathematical models in an attempt to measure trust, including Bayesian algorithm-based metrics [9] and belief theory-based models

[1] Graaasp (graaasp.epfl.ch): a PLE prototype.
[2] eBay (www.ebay.com): an online auction and shopping website.
[3] Epinions (www.epinions.com): a consumer review website
[4] Amazon (www.amazon.com): an e-commercial website.

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[10]. These models provide a theoretically sound basis for computing reputation scores, but they are too complex for average users to understand and too difficult to implement in real systems.

There are also some approaches using rating similarity to predict trust. Golbeck [11], for example, proposes an approach for computing trust in which several aspects of rating similarity that are believed to affect trust opinion in movies are integrated to compute trust values between people. The approach is based on the observation that, in many Web-based social networks, a significant percentage of users are completely isolated from most others, thus the social network-based trust measures are not applicable. However, those isolated users are usually the inactive ones who rarely contribute to the system and hence provide few ratings. Lack of ratings would probably be a problem for trust metrics relying on rating similarity.

A general observation of existing trust and reputation systems is that they tend to adopt global trust metrics, where for each entity in the community, a reputation score is computed to reflect how much the community as a whole trusts this specific entity. However, trust is more of a personalized concept greatly depending on personal experience, which means that the trust score of an entity could be different from the point of view of different users. Furthermore, each of the current trust and reputation systems targets to a particular domain, including e-commercial, product review, and movie review. In each domain, the context of trust is a shared belief in the whole community, such as the quality of service in case of e-commercial domain, or the usability of product in case of product review domain. In comparison, a PLE is a multi-disciplinary and multi-dimensional environment where resources and services are aggregated from heterogeneous sources. The contexts of trust could be diverse depending on different learning scenarios like group project of physic course, discussion of English learning, online meeting about Web 2.0 technologies, and so on. Thus, there is a clear need for a context-dependent trust model that accounts for various learning contexts in such an environment. Last but not least, instead of designing complex mathematical model-based metrics, the trust model should be simple enough for non-technical users to use. Given these requirements, effective trust and reputation mechanisms in PLE should take users' subjective views and learning context into account, as well as making it easy for average users to understand.

III. TRUST MODEL IN PLE

Intuitively, trust can be affected by a variety of factors, including personal experience, rumor, social rules and so on. There is no single trust model that will be suitable in all domains and applications. To comply with the specific requirements and constraints of PLE, trust is explored in four dimensions: trustor, trustee, context and visibility. The idea is to describe who trusts what in which context with which degree of visibility. In this section, we propose a 4-dimensional trust model dedicated to PLEs. The importance of these four dimensions is illustrated through example scenarios.

A. Trustor

The two parties involved in a trust relationship are referred to as trustor and trustee respectively. As mentioned previously, for a particular trustee, the trust value varies from the standpoints of different trustors, depending on various personal experiences. As an example, Alice strongly trusts Bob since they have been working together on the same project for several months. While Claire does not trust Bob at all as they have not collaborated with each other before. In short, *personalization* is a crucial characteristic that should be accounted for when computing trust. However, with incorporation of personalization into the trust model, computation complexity increases accordingly, which might bring about confusion for users. Therefore, the personalized trust metrics must be designed and presented in a straightforward way so that average users can easily understand and use them.

Although personalized trust metrics are more precise and tailor-made for individual users, they are still not sufficient to measure an entity's trustworthiness in the learning community. For new users who do not have much experience in the community and have no knowledge of entities' trustworthiness, it is more important to refer to others' trust opinions towards an unknown entity to reduce transaction risk. To this end, the *global* reputation score of a particular entity should also be considered as an essential factor, in terms of representing the trust opinion held by the community as a whole. In this paper, we integrate global and personalized trust metrics for the purpose of providing both a general and a personalized view of trust opinions. Concrete application of the two trust mechanisms will be illustrated in detail in Section IV.

B. Trustee

In a trust relationship, trustor is usually a person or an agent. While as the receiver of trust, trustee can be a person, a resource, a tool or any other entities in the system. For instance, a professor can be trusted because of his/her expertise, a book can be trusted because of its quality, and a tool can be trusted because of its utility. For a specific type of trustee, people tend to use a certain set of criteria to evaluate the trustworthiness. It's relatively easier to evaluate the trustworthiness of a document than a person, since the characteristics of a person are much more complex and could change over time. How the type of trustee influences trust relationship between two entities will be investigated in the user study hereafter.

C. Context

PLE is an open environment that aggregates people, resources, and services from a large variety of disciplines, such as physics, computer science, electrical engineering, and any other learning domain. Depending on different learning goals, the learning activities in PLE could also vary from group projects to independent study, forum discussion, and online courses. In such a complex environment, context plays an important role in how people assign trust. As an example, Alice trusts Bob in the context of English learning since Bob is a native English speaker, whereas she does not

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trust him in the context of ski learning as Bob is a ski beginner. Therefore, it's essential to integrate the factor of context into the trust model of PLE.

However, as a controversial concept, context is too complicated to define and represent. Major research efforts have been made to develop ontology-based context frameworks [12] [13], but the problem is that ontologies are very difficult to agree on in that different communities use different naming standards and interpret entities in different ways. Moreover, from a user's point of view, ontology-based context models impose an inconvenient way of organizing and classifying entities. To solve this problem, a simple and understandable approach to identify context and incorporate it into the trust mechanism is introduced in Section IV.

D. Visibility

The trust scores in existing trust and reputation systems are mostly publicly available to all members of the community. For instance, all eBay users can see what feedback (positive, neutral, or negative) a particular user has given to another user. Nevertheless, in some cases, people might feel uncomfortable to share their trust opinions with others. Especially when people express negative trust opinions, they might prefer to make them private in order to avoid retaliation from others or limit the negative social impact of the trust values they assign. Furthermore, these psychological reasons have been proven to lead to a positive bias of ratings in most reputation systems [5].

Due to these privacy concerns, three visibility types of trust are considered in our model: public, private and anonymous. Public trust score is globally visible in the entire community. Private trust score assigned by a user is particularly accessible to himself/herself or a certain group of users indicated by him/her. Anonymous trust score is accessible to all members anonymously.

Based on the analysis above, a 4-dimensional trust model is proposed by integrating the four factors that are believed to effectively describe how people assign trust in PLE. Let T_r denote trustor, T_e denote trustee, T_c denote context, and T_v denote visibility. A trust value can then be defined using the term $< T_r, T_e, T_c, T_v >$. As an example, $<$ *Alice*, *Bob*, *English learning*, *public* $>$ represents the trust value Alice assigns to Bob in the context of English learning publicly. The implementation of the trust model in a PLE platform is addressed in detail in Section IV.

IV. TRUST APPLICATION IN GRAAASP

A. Graaasp

Graaasp can be described as a Web 2.0 application that can serve simultaneously as an aggregation, contextualization, discussion, and networking platform, a shared asset repository, or an activity management system. The user interface of *Graaasp* is illustrated in Fig. 1. The structure of *Graaasp* relies on the extension of the 3A interaction model [14], which is intended for designing and describing social and collaborative learning environments. The 3A model consists of three main constructs or entities: **Actors** represent entities capable of initiating an event in a collaborative environment, such as regular users or virtual

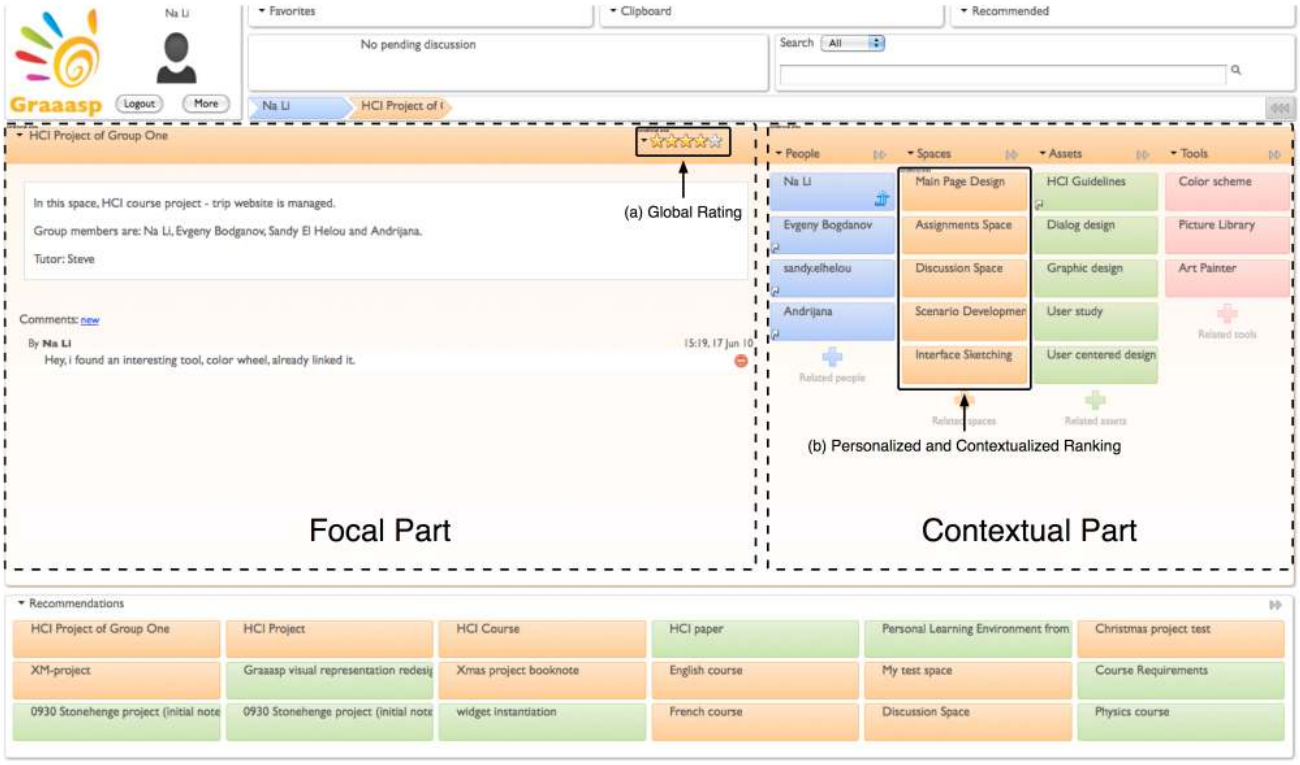

Figure 1. Graaasp User Interface

agents. Actors create collaboration spaces where they conduct personal and group **Activities** to reach specific objectives. In each of these activities, actors can take different roles, each of which consisting of a label and an associated set of rights. In addition, Actors produce, edit, share and annotate **Assets** in order to meet activities objectives. Assets can consist of simple text files, RSS feeds, wikis, videos or audio files. A fourth structural entity **Application** is added into the model to describe widget or gadget [15] that can be installed and executed within the Web pages. Applications can be any tools created or linked by actors.

As shown in Fig. 1, the user interface of *Graaasp* mainly consists of two parts: the focal part on the left side and the contextual part on the right side. The focal part shows the entity that is currently selected by the user. It can be a human (actor), an activity (space), an asset or an application (tool). The contextual part consists of the four columns of items, each of which represents one type of entities (actors, assets, activity spaces, tools) linked to the focal entity.

Instead of integrating complicated context framework, we simply define the current learning context as the combination of the focal entity and its related entities. A further explanation of the learning context is described through the following scenario: A group project called "*HCI Project of Group One*" is selected as the focal entity, within which there are four group members ("*Na Li*", "*Evgeny Bogdanov*", "*Sandy El Helou*", "*Andrijana*"), several activity spaces ("*Main Page Design*", "*Assignment Space*", "*Discuss Space*", "*Scenario Development*", and "*Interface Sketching*"), a set of assets ("*HCI Guidelines*", "*Dialog Design*", "*Graphic Design*", "*User Study*", and "*User Centered Design*") created by group members, and a number of tools ("*Color Scheme*", "*Picture Library*", and "*Art Painter*") linked by them. These entities, as a whole, construct the learning context.

B. *Applying Trust in Graaasp*

Different ways to apply and represent trust can be found in various online systems. Rating with the scale of five is the most widely used method to assign trust, which has been applied by eBay, Epinions, Amazon, and so on. Voting as "like" or "dislike" is also used to express trust opinions in a handful of systems including Youtube[5] and Facebook[6]. Additionally, LinkedIn[7] and CouchSurfing[8] adopt a reference or recommendation mechanism to capture the trust relationship between participants. There are other platforms like AllExperts[9] using ranking and FilmTrust[10] using numerals to represent the trustworthiness of users. In *Graaasp*, we use *rating* to capture and manifest global trust, and *ranking* to present contextualized and personalized trust, as *rating* and *ranking* are intuitive ways for average users to express their trust opinions. The trust model proposed in Section III is implemented into the system, where we integrate the four dimensions to construct the trust mechanism.

The detailed illustration of the global rating in Fig. 1 (a) is shown in Fig. 2. When a user selects an entity as the focal one, a rating score can be given to this particular entity in the scale of five. People, activity spaces, assets, and tools can all be rated once selected. Regarding the visibility of the rating score, three alternatives are provided: public, private and anonymous. The user is able to decide whether to make the rating opinion accessible to all the community members (public, anonymous) or restrict it only to a particular group of users (private). For every entity, an average score of all the ratings is computed, which is considered as the reputation score of this specific entity. This reputation score, which is visible in the entire community, represents the global trust perception and thus provides a social metric of trustworthiness associated with the entity.

Figure 2. Three Visibility Types of Rating

As mentioned previously, the learning context in *Graaasp* is defined by the combination of the focal entity and four columns of entities that are related to it. Within a particular context, users can rank the entities in each of the four entity lists by "drag and drop" action. As an example, the original ranking of activity spaces is presented in Fig. 1 (b). How the activity space of "*Interface Sketching*" is ranked at the top of the space list is shown in Fig. 3. This user-defined ranking of entities (generated by a specific user depending on a specific learning context) can then be considered as the personalized and contextualized trust

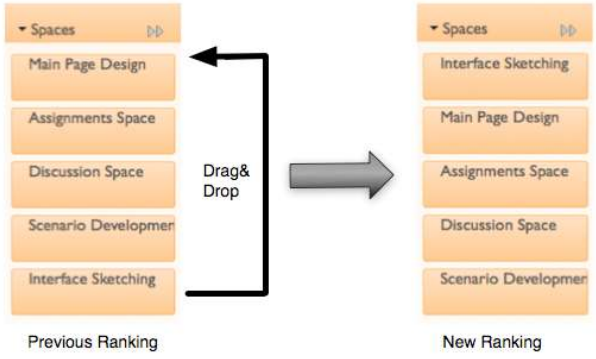

Figure 3. Ranking by "Drag and Drop" Action

[5] Youtube (www.youtube.com): a video sharing website.
[6] Facebook (www.facebook.com): a social network website.
[7] LinkedIn (www.linkedin.com): a business-oriented social network website.
[8] CouchSurfing (www.couchsurfing.org): a social network website for travelling.
[9] AllExperts (www.allexperts.com): a website for asking and answering questions.
[10] FilmTrust(trust.mindswap.org/FilmTrust): a movie review website.

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assigned by the user. Explicitly ranking "*Interface Sketching*" at the top of the list suggests that this specific user strongly trusts this activity space within the current context. The customized ranking not only provides users a convenient way to organize content according to their preferences, but also enables the system to capture users' trust opinions for future use including context-dependent recommendation and effective search. As far as the visibility of trust is concerned, the user is able to keep the ranking only to himself/herself or share it with a certain group of community members indicated by the user.

V. PRELIMINARY EVALUATION

To evaluate the usefulness of the trust mechanism in *Graaasp*, a user study is conducted with participants who would be typical users of the system. The evaluation methodology and main findings are discussed in this section.

A. Evaluation Methodology

Typically, user studies are used to confirm the design decisions and find any problems that have been overlooked. They can range from closely controlled experimental studies testing specific hypotheses to field studies where the system is deployed for real usage and interviews are used to assess its usefulness and usability [16]. Our study falls into the first category, where the *Graaasp* system is introduced to potential users and in-depth interviews are carried out, aiming at determining whether the design of the trust model is suitable for the intended audience and for its intended purpose.

For each participant, the study consists of two parts. The first part is an introduction of the overall *Graaasp* system and the particular features related to trust mechanisms. The second part is an individual interview with carefully defined user questionnaire. During the study, participants are encouraged to "think aloud", in order to obtain running commentary while they are interacting with the system.

The user questionnaire is composed of Likert-scale questions [17] with 5-point preference scale (strongly disagree, disagree, neutral, agree, and strongly agree), multiple choice questions and open questions. The questions can be grouped into the following categories: usefulness of global trust, usefulness of trust visibility specification, usefulness of personalized and contextualized trust, and influence of trustee on trust. The user questionnaire is summarized in Table I.

B. Data Collection

The user study is conducted with ten engineering university students, who are the intended audience of the *Graaasp* system. All of them are graduate students between the age of 20 and 30. All participants are frequent Web users who visit the Internet daily and most of them have some experience of using online learning systems. All informants claimed that they were familiar with the rating, voting, ranking or similar features in online systems and used them from time to time.

Data was collected through user questionnaires and interviews. Two experimenters stayed with each participant throughout the session, observing his/her reactions, asking questions, and noting feedback of the participant. Ten individual interviews were carried out and ten questionnaires were successfully completed.

TABLE I. USER QUESTIONNAIRE

I	**Usefulness of global trust**
	I would like to *see* the global average rating score for entities.
	I would like to *provide* rating scores to entities.
II	**Usefulness of trust visibility specification**
	Can you think of a scenario where you would like to give a public rating? Can you think of a scenario where you would like to give an anonymous rating? Can you think of a scenario where you would like to give a private rating? When you provide a private rating, to whom do you think it should be displayed?
III	**Usefulness of personalized and contextualized trust**
	I would like to rank by myself the entity lists (Actors, Activity Spaces, Assets, and Tools). I would like to share my personal ranking of entities with the following people. (None, Friends, People in current learning context, Others)
IV	**Influence of trustee on trust**
	I find it useful to rate one or several types of entities. (People, Assets, Activity Spaces, Tools, None)

C. Results and Discusstion

All participants stated that the global rating score was useful in providing a general assessment of the quality of entities, which would assist them to select and filter content before going into details of it. They also requested for rating-based search and top-N recommendations. Some indicated that besides rating score, comments would also be valuable to give references of quality. Compared to viewing a global rating score, 9 out of 10 participants were willing to provide rating scores, whereas the remaining one explained that he would just like to view the Web content instead of reviewing it. The results suggest that with regard to the rating system, most users would not only be a viewer or consumer, but also a contributor in the rating system. This facilitates fostering a collaborative assessment environment in PLE, which is the exact objective of the trust mechanism.

Regarding visibility of trust, 7 participants pointed out that they would mostly make ratings public since they wanted to share their rating opinions with other community members. This is consistent with our previous finding that users were shown to be willing to contribute and offer guidance to others in the system. As far as anonymous rating is concerned, 4 students claimed that they would use it for negative rating opinion. We believe that the reason behind this is trying to avoid retaliation from the recipient of the rating. However, there are also other students indicating that anonymous rating would cause unfair cheating rating behaviors, since it is possible for a malicious user to abuse the anonymous rating to sabotage others. As for the private rating, 8 out of 10 participants thought that it was useful for confining the rating opinion within a small range of users

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instead of spreading it among the entire system. It is worth mentioning that they also preferred to define by themselves the group of users who had access to the private rating scores.

Furthermore, all participants stated that the personalized and contextualized ranking feature was helpful for prioritizing and organizing entities according to their own preferences. They thought that ranking by "drag and drop" action was quite practical and convenient. 7 participants were willing to share their personalized rankings with others, especially with users in the same learning context. While 3 participants preferred to keep the ranking private, because they thought that the personal ranking did not concern others.

Another interesting finding is that 9 out of 10 participants indicated that while they would like to rate assets, activity spaces, and tools, they felt uncomfortable to rate people. The reason behind this was explained to be the fact that they usually did not like to judge others directly since the characteristics of a person were multi-dimensional and hence difficult to assess with only a single numerical score. Instead, they felt more comfortable to evaluate the products or contributions of a person, as the quality and utility of items were easier to assess. This provides us with some insights as to how to improve the trust and reputation metrics for people in the future. A possible approach could be to calculate a person's trust and reputation score based on his/her contributions and behaviors in the system, rather than computing others' rating opinions for him/her.

To sum up, the evaluation results reveals that users not only accept the proposed trust mechanism as a way to get a general assessment of content quality, but also use it for representing personalized and contextualized preferences. Moreover, users are satisfied with being able to define the visibility of their trust opinions. Last but not least, rating people directly is not considered as a suitable approach to assess the trustworthiness of them.

VI. CONCLUSION AND FUTURE WORK

The popularity of Web 2.0 social media has brought about a large amount of user-generated content. To design effective trust and reputation mechanisms that facilitate selecting and recommending trustworthy content becomes the recent research challenge. Particularly, in PLE platforms where multi-disciplinary resources and services are aggregated from heterogeneous sources, there is a clear need for personalized and contextualized trust metrics depending on different learning goals. In this paper, to comply with the specific requirements of PLEs, we explore trust in four dimensions: trustor, trustee, context and visibility. A trust model has been proposed and implemented within a PLE prototype. To evaluate the usefulness of the trust model, a user study has been carried out through questionnaires and interviews. The results show that users are satisfied with the mechanism where trust is tackled not only on a global scale, but also on a personal and contextual scale. Being able to fully control the audience of trust opinions is also accepted as a useful feature. However, suitable trust and reputation metrics for people still need to be investigated in the future.

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