Semantic Web Technologies for Supporting Peer Assessment

Lilia Cheniti Belcadhi[1] and Serge Garlatti[2]

[1] PRINCE Research Unit ISITCom Sousse University, Sousse, Tunisia,
lilia.belcadhi@infcom.rnu.tn
[2] Telecom Bretagne, Brest, France,
serge.garlatti@telecom-bretagne.eu

Abstract.

We are interested in three technologies, Semantic web and ontologies to deliver peer assessment as part of Inquiry based learning (IBL) environment. Introducing peer assessment can be a way to force students to take the responsibility to make a judgment about the actual contribution of each of their peers and to enrich their knowledge by assessing the work done by other learners. Delivery of peer assessment in these environments is based on the use of Web 2.0 and semantic Web and aims to deliver peer assessment activities adapted to learner specific situation, profile and context. In this paper we study the possibilities to produce peer learner assessment in IBL environments through an analysis of a peer assessment scenario in these environments and main issues to be faced. We finally propose a description of main semantic models needed to produce peer assessment activities in the learning process.

Keywords: Mobile and Pervasive Learning, Social Media, Semantic Web, Linked Data, Peer Assessment, Ontologies, Scenarios, IBL

1 Introduction

Peer assessment is a special form of collaborative learning, in which peer students learn through assessing others‟ work. It has been successfully employed in a variety of academic disciplines, and which is considered to be effective in developing student's higher cognitive skills. It is usually defined as a scenario where students review artifacts as the learning outcomes of other students on the basis of a set of criteria. Then, when students evaluate each other, they think more deeply, see how others tackle problems, learn to criticize constructively, and display some important cognitive skills such as critical thinking. This type of assessment helps to develop the acquisition of self-directed learning skills, considered as a key objective of Inquiry Based Learning, as students participate in the assessment experience. For instance in science domains, inquiry-based learning may be defined by engaging students in: i)

Authentic and problem-based learning activities which are ill-defined and have several answers; ii) A certain amount of experimental procedures, experiments and activities involving practical experience of equipment and including searching for information; iii) Self-regulated learning sequences where student autonomy is emphasized; iv) Discursive argumentation and communication with peers ("talking science"). Courses based on Inquiry Based Learning (IBL) have to make assessment more learner-centered and to offer mechanisms to observe the knowledge process (how well the learning took place) and its outcomes (what has been learnt in terms of knowledge, understanding, skills, etc.). Among assessment methods for IBL courses, peer assessment is considered as the most successful method in IBL courses. Indeed, it helps to develop the acquisition of self-directed learning skills, which is considered as a key objective of IBL, as students participate in the assessment of their peer work. It encourages students to reflect on their own approaches to assessment tasks to develop critical reasoning skills and reflection [4].

From an educational perspective, social media applications fit well with IBL courses as they provide spaces for collaborative knowledge building, self-regulated learning sequences. In other words, social media applications are good tools to support IBL courses. Unfortunately, “keyword” search engines, available inside or outside such tools are unable to filter and reuse automatically information to provide the relevant one to the learners. On the contrary, the semantic web approach is able to deal with such issues. Thus, the Semantic Web [3] can offer useful venues towards achieving our objective, particularly with respect to the notion of ontology, which plays a key role in facilitating the sharing of meaning and semantics and assessment material, can be semantically annotated for every new assessment request. Moreover, ontologies enable us to formalize the learning and peer assessment process and the corresponding contexts to provide an accurate support.

The main contributions of the paper are: i) The design of peer assessment ontology dedicated to IBL courses and integrated to the other required ontologies; ii) the peer assessment model dedicated to a generic IBL activity model defined as a specialization of the Online Presence Ontology; iii) Several ontologies and semantic web technologies to implement the peer assessment activities as part of the learning process; We aim to integrate peer assessment activities in an inquiry-based scenario in IBL environment and to demonstrate how semantic web technologies enable such assessment process. The objective is to guarantee selection, contextualization and rendering of unstructured content across tools as needed for peer assessment delivery [15].

The paper is structured as follows. The first section presents the state of the art for peer assessment. In section 3, we describe the different activities of a general peer assessment scenario. Then, a generic IBL scenario including peer assessment activities is explained and we outline the main challenges and issues according to such type of scenario. We finally detail the main semantic models needed to ensure data exchange and interoperability between various social media applications. We also present some parts of the semantic model related to the peer assessment activities. Thus, we give an idea about a possible way to implement the proposed peer assessment model. Finally, a conclusion is given.

2 Peer assessment

Peer assessment is defined as a method in which students engage in reflective criticism of the products of other students and provide them with feedback using previously defined criteria Peer assessment recently has often been applied as an alternative assessment method in many different fields [8]. Sluijsmans and Van Merrienboer (2000) has identified a peer assessment model be used for any training and that needs to take account of the following sub skills: (a) defining assessment criteria—thinking about what is required and referring to the product or process; (b) judging the performance of a peer—reflecting upon and identifying the strengths and weaknesses in a peer's product and writing a report; and (c) providing feedback for future learning—giving constructive feedback about the product of a peer [18].

In particular in Inquiry based learning environment, peer assessment helps to develop the acquisition of self-directed learning skills (a key objective of IBL) as students participate in the assessment experience [14]. Indeed Assessment, in IBL environments need to focus on how students integrate the whole learning process as distinct from what has actually been learnt. We need to provide assessment, which is more learner-centered. In this context and in particular in technology enhanced learning environments, peer assessment, gives the students the opportunity to evaluate and learn from peers' work and comments, then work with self-comparison; discover the shortcomings of their own work, and determine the right way to improve their works. Thus, the process enhances students' meta-cognitive understanding about their own learning process and develops their social and transferable skills. Students can then reflect on their own approaches to assessment tasks, to develop critical reasoning skills and skills of reflection [18]. Typically, e-assessment refers to using technology to manage and deliver assessment and deployed in e-environments. Peer e-assessment deployed in technology enhanced learning environments is considered as a subcategory of e-assessment. A major challenge to face for e-assessment is the diversity of resources and tools. It is therefore necessary to link the different knowledge sources involved in e-Assessment [16]. One possible solution would be to use Semantic Web, which has been used during the last years in many applications for e-assessment to provide content personalization and organization [6]. Indeed Ontologies have been used for e-assessment application for different purposes mainly to capture the structure of a domain and experts representations of the domain, to score knowledge map, package and deliver content at different grain sizes, to be part of a recommender system and to provide a structure the automated design of assessment

In particular we have observed that in the context of e-assessment, ontologies have been used mainly for providing a structure to guide the automated design of assessments, which is also the purpose of this research work. Our objective is to describe a model that can guide the design of peer e-assessment in IBL environments; In [16] an ontology is proposed that permits to conceptualize the e-assessment domain in general, and not specific to the peer assessment technique and gives consequently a structure to guide the automated design of e-assessment. The majority of the ontologies proposed for e-assessment are lightweight ontologies, which model a part of the assessment domain without considering pedagogical aspect. For example we find in [2]

ontologies that have been used as a source for mining analogies for questions used for student assessment to avoid problems of hand coding. Heavyweight ontology for e-assessment domain is proposed in [17]. However the reuse of semantic resources raises many challenges and we need for example the generation of assessment items which can help identifying a relevant domain model as described in [9]. In our research work we propose a heavyweight ontology for peer assessment that describes the peer e-assessment but also focus on pedagogical process to generate and deliver this ontology. We also distinguish between intra peer assessment and inter peer assessment. The first type concerns the case where the students assess the product of what they themselves have produced as a group. The second type concerns the case where students assess the work of another group, using assessment criteria. Besides we found that different processes of peer assessment feedback were implemented by these tools follow an object-oriented approach and a domain-specific modeling approach [20]. A deep review of the effectiveness of peer assessment feedback and process is given in [8].

3 Peer Assessment Scenario

According to the previous peer assessment study, we detail a general peer assessment scenario. Based on the three core tasks of the peer assessment activity, we have defined, a typical Peer Assessment scenario is composed of the six following steps [12].

a) Step 1: Initialization. During this step the tutor prepares all necessary elements for the peer assessment project progress and identifies all items related to this project (Definition of the elements of the project, Problem description, Schedule, etc.).
b) Step 2: Learning activity which will be later assessed
c) Step 3: Performing Peer assessment. In this phase, learners must first participate in determining the assessment grid and then evaluate the work of their peers achieved in the previous phase based on the defined grid. It is composed of the following two stages

   Stage 1: defining assessment grid. At this stage, we want to involve the learner in the definition of an evaluation grid to reinforce his/her autonomy and so that he/she will be aware of the different criteria used in the peer assessment. Learner has to evaluate assessment criteria. He/she gives his/her opinion in relation to the proposed criteria that helps the tutor to determine the weight for each criterion.

   Stage 2: producing peer assessment. During this stage, each learner is responsible for assessing a finite list of work done by their peers during the learning phase using the evaluation grid.
d) Step 4: Analyzing results of assessment. Tutor at this stage, analyzes the quality of assessments conducted by learners, as well as the precision and correctness of their assessments. Learners can also read the comments of their peers and which are discussed together.
e) Step 5: Re-assessment. This phase represents a second chance given by the tutor for learners who have attributed notes outside the interval of convergent

notes of the evaluated work. During this phase we repeat the same activities of the "producing peer assessment" stage in the step before.

f) Step 6: Calculating the final grade. This is the last step in which each student will have the final grade of his work.

This typical peer assessment scenario is composed of 6 steps. We consider that the first step is performed only once to prepare all conditions needed for application of this scenario. We therefore propose to ignore this step. Another observation is related to the last two steps. Indeed these two steps are mainly used in summative peer assessment, as the grade obtained by the learner during the peer assessment process will be accounted for its final grade. In this paper, we propose to focus on the implementation of formative peer assessment process. We therefore consider only the three following steps: step 2, 3 and 4. Now, these steps are applied in an IBL context.

3.1 Peer assessment in an IBL generic Scenario

We choose an example based on a historical problem of technology - the swinging bridge of Brest over the Penfeld (1861-1944). First of all, the complete problem to solve, dedicated to in-service teachers at primary school, is composed in the three following sub-problems: i) Problem 1: understand the industrial landscape in the area of the bridge (Brest is a shipbuilding arsenal for the Navy)[1]; ii) Problem 2: understand the historical and technological method of problem solving that led to the construction of the swinging bridge[2]; iii) Problem 3: understand the rotating mechanism of the swinging[3]. For the sake of simplicity, we focus only on the problem 1 in this paper.

In this section we include peer assessment activities in a generic Inquiry-based learning scenario described in [10]. Peer assessment may be introduced in all activities described in the scenario. For the sake of simplicity, we propose to focus on the peer assessment process that occurs in the last two phases (4 and 5), which is related to the collaborative search and writing of the group report with a use of mobile devices for data generation and access anytime, anywhere and in situation. A typical scenario (a generic one including some peer assessment activities) for an inquiry-based learning approach, adapted to the problem 1 and the teachers' curriculum is as follows:

1. Problem analysis in small groups: the problem will be based on an open question, such as evolution of industrial landscapes. Each group reads the problem in depth to establish which "concept" is known or unknown.
2. Activation of prior knowledge through small-group discussion (at school): the group has to determine the well-known keywords (as prior knowledge) and the unknown keywords (knowledge to acquire), in this case concerning bridges and cranes. A first bibliography of relevant definitions, basic resources on the subject is rapidly established on a social bookmarking tool, that enables sharing in a group, annotations and tagging, for example Diigo. Some keywords, or tags will emerge from this first information seeking; A list of open questions and knowledge to acquire is build on a group shared document; Each group's member will write a small post in her e-portfolio/Blog to relate her/his observations on

[1] http://plates-formes.iufm.fr/ressources-ehst/spip.php?article17
[2] http://plates-formes.iufm.fr/ressources-ehst/spip.php?article18
[3] http://plates-formes.iufm.fr/ressources-ehst/spip.php?article24

group's and owns methodology. He/she will be free to publish it and to allow comments from other students or not;

3. Elaboration of a common strategy to find needed information: for instance, why a bridge, where and how? The group explores the information space, quickly. It defines the set of activities, which will be achieved in cooperation (activities distribution) or in collaboration (all together).

    a) An activity list is collaboratively defined to work on open questions and assigned to group's members or sub-groups; Opportunity of dividing the group to combine site visit and information seeking in navy museum, local public records, and on the web, is proposed by the tutors;

4. Collaborative work and exploitation: (at school and on site, Brest Harbour). A first work may be to localize current. and ancient buildings on a map to define the track of the walk. During the walk, they have to take pictures and interact with the tutor, to gather a maximum amount of information. After coming back, they have to upload, organize and publish pictures.

    a. The group can communicate by means of synchronous tools, whether chat or vocal, to suggest some information seeking to other group's members; Data collected on the web will be collected on social-bookmarking tool. Other sources may be digitized, to enable sharing; Pictures, videos, sounds may be taken, geo-localized, tagged and uploaded on the web; Based on geo-localisation, mobile devices can suggest to consider some noteworthy landscape's element; the tutor can check keywords, conversations, and possibly tracks followed, that relevant concepts or landmarks are treated, and suggest further exploration. It can be done synchronously (remote communication facilities); Then, a meeting is organized with the whole group to analyse all information collected; Each group's member writes a small post to relate their observations on group's and own methodology, and possible improvements;

    b. Peer assessment sub-activity:

    For this sub-activity intra peer assessment is used to evaluate the shared bibliography and user collected content within each group. At this stage peer assessment is also very helpful as it permits to assess the individual contribution of each learner in the group work. User collected data will be shared using social media tools. For the peer assessment process, it is necessary to filter and select the most appropriate resource according to the learning activity and the learner needs:

    i. Step 2: *Learning activity which to be assessed:* Each group is asked to evaluate internally the data collected by its members.
    ii. Step 3: Performing Peer assessment.
    - *Stage 1: defining assessment grid*. A set of intra peer assessment criteria is established within each group to analyze the data information collected. The grid is discussed using the group'blog.
    - *Stage 2: producing peer assessment*. There is a need to get a feedback from the learners on the deposited resources, by sharing them on the social media applications of each learner, and then the learner rotates

around the resources, leaves comments, suggests and critiques on i.e. a forum available on the group coordinator social media applications.

iii. Step 4: Analyzing results of assessment. Group members at this stage, analyze the quality of assessments conducted by the peers from their group, they can also read the comments posted by their peers on the shared data and which are discussed together using their group's blog or forum.

5. Collaborative report writing, (social knowledge construction), final problem solving in classroom by exploitation of corpus (gathered information, maps, pictures, etc.).:
   a. Learners will write collaboratively their report using Tools such as Google Docs or Wiki and will then publish it online to other groups.
   b. **Peer assessment sub-activity:** This sub activity concerns an inter peer assessment between groups of learners, to evaluate the reports produced by each group and shared using social media
      i. Step 2: *Learning activity which to be assessed:* Each group is asked to evaluate all reports produced by other groups.
      ii. Step 3: Performing Peer assessment.
         - *Stage 1: defining assessment grid*. A grid is defined and which is composed of inter peer assessment criteria related to the quality of the generated product. Learners should discuss and agree together with the tutor on the performance criteria to use for evaluation of work done by various groups. The tutor has first to upload the assessment criteria that need to be used to evaluate the reports. Learners may post their comments on forum, discuss on their blogs these assessment criteria and ask for clarification. They should also negotiate the scoring scales, to be used in the peer assessment process. Communication tools and shared forums have to be used to design, negotiate and validate the inter peer assessment criteria.
         - *Stage 2: producing peer assessment*. During this activity, learners should provide constructive feedback about the reports done by other groups. For that, every learner will be asked to deliver an assessment scheme that includes his/her appreciation and share it with his/her group members on document sharing tools.
      iii. Step 4: Analyzing results of assessment. Learners are finally invited to make their reflection explicit. Assessment reports should then be available for all learners and discussed with the tutor via i.e forums.

6. Institutionalization (tutor synthesis, in classroom). As concept coverage, activities lists and deliverables, as well as final reports, are available; Tutor makes a result synthesis and points out difficulties encountered by reusing available information; Finally, each student will make a final synthesis of the sequence, underlying strengths, weaknesses, and progress made;

More precisely, the instructions given by the trainer for activities, at the stage 4 of the above-mentioned scenario, are: from a walk up the Penfeld from Lift Bridge Recouvrance (meeting place on the parking lot of the Tour Tanguy) and by relying on the gathered historical information before the visit about cranes, bridges and views of the arsenal, you have to: i) Photograph all elements of the current landscape with

historical aspects about cranes and bridges of the arsenal; ii) Locate the different elements on a current map of Brest; iii) Identify and photograph the actual bridges and cranes linked existing bridges and cranes from previous ones: What "continuities"? What "ruptures"? on the site, iv) Store and publish information on the corresponding tools. In the next section we propose to emphasize the challenges that have to be faced for the delivery of peer assessment activities.

3.2 Scenario analysis and challenges

According to the proposed scenario, we can identify different categories of relevant entities: learners, tutors (trainers), learners' group or subgroup, different locations, paradigmatic activities for inquiry-based learning approach distributed among learners and/or group of learners, the concepts of the domain considered (bridge, crane, etc.), communication tools and more generally social media applications, devices. For information seeking, one can see that it is necessary and/or useful to retrieve, for instance, information retrieved and/or produced by learners, learner groups or subgroups, maybe according to a specific activity and/or location and more generally to a specific situation. Retrieved and produced information is distributed across web 2.0 tools.

Thus, it is necessary to retrieve information, activities, people, etc. in different tools distributed over Internet. Unfortunately, social media applications are data silos. In other words, data are unavailable on the web. Only people may have access to data, not computers. Reuse and exchange of data among social tools are only possible by means of API – that is to say manually by mean of one API per tool. Semantic web approach enables us to solve the problem of finding information by avoiding polysemy and reducing the number of results. The semantic web offers tools and infrastructures for semantic representation by means of ontologies. The latter fosters interoperability at semantic level because it provides a unique meaning for a concept and a relationship in ontology. Our objective is based our approach on Semantic Web for peer assessment and identify the following potential beneficial of Semantic Web Technologies. Ontologies can provide a precise semantic for the learning domain, the learning activities, the different categories of stakeholders, the collected and produced content, the learning context and all peer assessment activities and components (criteria, grid, …).

4 Semantic models for peer assessment in IBL

In order to tackle the challenges stated above, we need to maintain a certain number of semantic models, which not only allow us to handle and manage various types of data, but also enable various techniques of assessment and learning over heterogeneous tools. In a previous work we have already detected the needed models to provide assessment in pervasive learning [5]. These models, and their possible features, are outlined in the following:

- **User model:** We need to receive timely information on the various users. We may have different categories of users, learners, groups, tutors. Taking into consideration the assessment activity, users may have various roles such as assessment criteria designer, inter peer assessor, intra peer assessor. Ontologies such as SIOC and FOAF may help us receive information on the fly about users of web 2.0 tools.
- **Activity model:** This model permits the organization of the learning and assessment activities in order to provide learning sequence according to IBL scenario. This model is a specialization of the "Activity" concept in the OPO ontology (Online Presence Ontology), which formalizes the IBL learning activities according to the five phases of scenario (cf. section 3.1**). The Peer Assessment model is** included in the Activity model proposed [10]. In order to provide assessment we need to be able to select the appropriate assessment activities according to the assessment scenario and its context of deployment (Time, place, used devices, used communications and collaborations tools …). To do so, the learner should be able to select the resource for which they have to deliver the assessment, gain access to the evaluation criteria, and post their comment on the peer assessment criteria to receive further explanation from their peers and tutors.
- **Domain model:** The delivery of assessment in pervasive environments should be grounded in an efficient manner to retrieve key resources. This task can be achieved through metadata annotation of the assessment resources. In addition, we should refer to domain ontology and make it easier the retrieve and select resources that are adapted to a given domain.
- **Resource model (metadata model):** The domain and resource models are used to index resources. Some metadata can be generated automatically (sometimes on the fly) from the tool databases according to common vocabularies like Dublin Core, SIOC (SIOC, http://rdfs.org/sioc/spec/), FOAF (FOAF, http://xmlns.com/foaf/spec/), OPO (OPO, http://onlinepresence.net/ontology.php) etc. Most of these vocabularies are lightweight ontologies that can fit well database schemas of web 2.0 tools. On the contrary, learners and/or teachers need to define the relevant domain concepts describing a post (for instance).

5 Peer assessment ontology model

This ontology permits to describe the peer assessment activities. Based on the scenario described above, this activity can be generally composed of three sub activities: The first activity concerns the preparation of the assessment criteria in proposing a grid, including criteria definition, negotiation and validation. The second is about providing the feedback by grading of the peer work, where peers are asked mainly to fill the assessment form. The third concerns the assessment feedback delivery by writing and sharing the assessment report for inter and intra peer assessment discussion between peers and tutors of the peer reports. The peer assessment activity is considered as one of the activities provided in the IBL activity model. The left part of figure 1 shows that the peer assessment activities are subclasses of the learning activity.

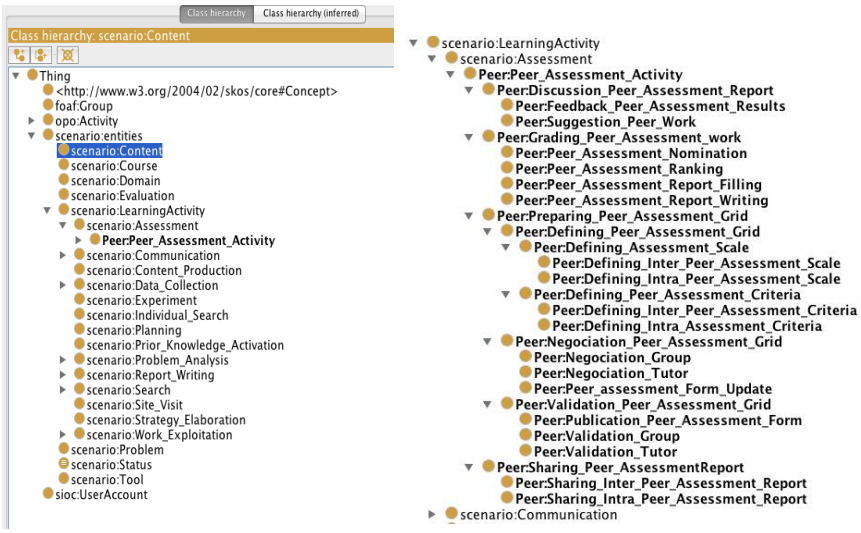

Figure 1: Activity model and Peer Assessment activities

Figure 1 shows also the peer assessment ontology which included in the scenario ontology. Based on the scenario described above, this activity can be generally composed of four sub activities: the first activity concerns the preparation of the assessment grid, including its definition, negotiation and validation; the second is about the grading of the peer work, where peers are mainly asked to fill the assessment form and write their assessment report; the third deals with the sharing of the assessment report for inter and intra peer assessment and finally the last one focuses on the discussion between peers and tutors on the peer reports. Assessment Content and corresponding semantic metadata can be extracted on the fly from social media applications and by specific modified plugins (sioc_export) and stored in an RDF repository. Several light ontologies (SIOC, FOAF, DC, RDF, RDFS, OPO) are used to acquire semantic metadata automatically and to instantiate the different models. The OPO ontology enables us to describe user "activities" by means of the concept "action". An activity has different status: Inactive, Ongoing, Suspended and Terminated. It can be realized by a learner or a learner group and may provide outcomes linked to it in particular tools. Thus, it is possible to link content, learners and assessment activities. Assessment activities are chosen and assigned by learners' groups. It is also the case for all learning activities.

The peer assessment ontology model can be integrated in the SMOOPLE environment [11], which is a Semantic Massive Open Online Pervasive Learning Environment based on a set of social media tools and a semantic web approach, more precisely on Linked Data. The SMOOPLE semantic services are in charge of managing semantic models, extraction and storing of data produced during activities, making queries available as web services and answering to semantic queries. The semantic web server (semantic services) is based on Jena. Users can interact with social media applications and specific widgets. They enable them to access information (in a pull mode at pre-

sent). The first version of widgets was implemented using UWA API[4] proposed by Netvibes.

We designed different widgets to retrieve information from a learner, a learner group, the domain model and the tags, the course, the learners and the activities. For activities and groups, it is also possible to create, define and modified groups and activities. At present, we design and develop the new version of the widget based on HTML 5, java, Javascript and JavaServer Pages[5]. The choice of this technique is justified by the fact that this form of interface may easily be embedded in most user interfaces and tools and in particular in social media applications. To support peer assessment activities, it will be necessary to specialize the current activity widgets. Several Web based assessment tools have emerged; some of them implement peer-assessment methods [7]. Some systems such as, Peer Grader, the Online Peer Assessment System (OPAS) have in addition some abilities for assignment uploading and reviewing as well as groups management and discussions and many others web-based tools that are described in [19] [1].The Most of these systems focus on the automation of the peer assessment process and the grading of the activities realized by the peers. They do not focus on an IBL scenario, and do not use semantic web technologies. Our peer assessment ontology is integrated in an IBL activity model and facilitates searching and filtering of content distributed in various social media applications.

6 Conclusion and future Work

Assessment is an important task in the educative process as it allows learners to get information about their progress. In this paper, we have presented an approach for supporting learners and tutor for peer assessment pervasive learning process. Our assessment scenario is built on ontologies that permit to acquire automatically semantic metadata and to guarantee seamless access to information across tools for enabling effective collaboration and assessment. The semantic web offers indeed tools and infrastructures for semantic representation by means of ontologies. The next step is to put in place the widget for peer assessment and to evaluate the use of this widget for IBL courses it use in various curriculums.

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