Improving the Workspace Awareness of Authors in Asynchronous Collaborative Authoring of Learning Designs

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Abstract: Creating adaptive learning resources is a complex, time-consuming process. Problems emerged regarding interoperability, reusability, and collaboration. This paper discusses a collaborative authoring approach to develop adaptive learning resources. The contribution of this paper is twofold. The first contribution is the analysis of the most suitable learning standard for representing adaptive learning resources and to be used for collaborative authoring. It is gained from an analysis and experiments through designing some small cases in various learning standards. The second contribution is the analysis of the implication of two collaborative features: *Notes* in which authors can leave comments and *History* which records provenance information. It is gained from a Between-group experiment. One finding shows that IMS Learning Design (IMS LD) has more advantages than other learning standards. Another finding shows that *Note* and *History* have positive implications for collaborative authoring of adaptive learning resources represented in IMS LD.

Introduction

Collaborative work for designing courses is not a new concept in education. Former research studies found that teachers or instructional designers work together and carry out brainstorming and discussions with their colleagues in designing instructional strategies (Christensen and Osguthorpe, 2004; Kenny et al., 2005). These studies also found that such interaction influences teachers' work more than instructional design theories. In the context of adaptive learning, collaborative work is important. The development of learning resources by a single teacher will be time consuming, in that the teacher needs to spend a great deal of time for assimilating important aspects of learning, developing instructional design, and creating learning materials. Furthermore, this process requires teachers to be expert in all topics covered in the course (Brusilovsky, 2003; Caplan, 2004; Kearsley, 2000). To date, there has been a lot of effort on adaptive learning (Brusilovsky, 2003; De Bra et al., 2006; Foss and Cristea; Hendrix et al., 2008). The produced authoring tools enable authors to reuse other authors' work, but do not support collaboration. Although reuse enables more than one author to contribute in authoring learning resources, it is not an appropriate approach for group work. Group work is not merely about a collection of people individually working to perform a task.

Reuse itself is not free from problems. A problem of interoperability will arise since the resources are represented in various languages. Interoperability can be gained in two ways; by imposing a transformation function to translate one language to other languages or by conducting a standard as a common language. The former was applied to former Adaptive Educational Hypermedia systems (AEH) and for interoperability between two AEH: MOT and WHURLE (Stewart, 2006) or MOT and AHA! (Cristea et al., 2005). The transformation includes translating terms introduced in one authoring tool into other terms which have similar meanings in the target authoring tools. This approach requires authors (teachers in this case) to have knowledge of both languages. A lack of related knowledge results in different interpretations of similar terms. Another drawback will emerge when there are some terms in the source language that do not have similar terms in the target language.

A learning standard solves the problem in that it offers the interoperability of syntax and meanings of learning artifacts. In addition, the use of learning standards is important in computer-based or web-based learning environments. The rapid growth of open content systems and authoring tools that produce reusable learning materials potentially give teachers an advantage to reuse the materials for their courses. On the other hand, a problem related to the lack of interoperability has arisen since the materials are represented in various languages and formats. In former research, interoperability could be gained by two methods; by implementing transformation functions or by applying a standard as a common language. The former has been applied in Adaptive Educational Hypermedia (AEH) to translate artifacts produced by an AEH system expressed in a

particular format into other formats, thus making it reusable for other systems. This method was applied to MOT and WHURLE (Stewart, 2006) and to MOT and AHA! (Cristea et al., 2005). The transformation includes translating terms introduced in the source system into other terms which have similar meanings in the target system; however, a potential problem in this method is that some terms are lost in translation. This happens when there are some terms in the source language that do not have similar terms in the target language, or they have the same name but with a different meaning. A learning standard solves the problem in that it offers the interoperability of syntax and meanings.

This paper discusses a proposed collaborative authoring approach of adaptive learning resources. The contribution of this paper is twofold. The first contribution is the analysis of the most suitable learning standard for representing adaptive learning resources to be used in collaborative authoring. This is gained from an analysis and experiments through designing some small cases in various learning standards. The second contribution is the analysis of the implication of two collaborative features: *Notes*, in which authors can leave comments and *History*, which records provenance information. This is achieved from a Between-group experiment with questionnaires. The rest of this paper discusses the motivation of choosing IMS LD through a comparison of some learning standards and then presents some related work in collaborative authoring and workspace awareness. Afterwards, the research methodology applied in this research is presented followed by the experiment results and related discussion. The final section presents conclusions and suggestions for future work.

Why Learning Designs? An Analysis of Learning Standards

Until recently, there have been a number of learning standards that could be classified into two groups: learning object/content standards, such as IEEE Learning Object Metadata, Sharable Content Object Reference Model (SCORM), and learning design standards, such as IMS Simple Sequencing (IMS SS) and IMS Learning Design (IMS LD) for structuring learning activities (Consortium, 2012). We analyse such standards to find the most suitable one for collaborative authoring of adaptive learning resources, and found a lack of pedagogical expressiveness in learning content/object standards. They enable authors to assemble learning objects into a flow of objects but without pedagogical strategies. From a learning object perspective, learning is viewed as a selection of suitable materials for learners, a delivery of a sequenced learning content from teachers to learners and an assessment of learners' progress. The Learning Design perpective, on the other hand, considers that learning is not merely about a sequence of learning content to be presented to learners, but also about how they are delivered to learners and how learners can gain knowledge. From this perpective, learning is carried out according to a flow of learning activities considering that students would learn better if they became actively involved in learning processes.

In this research, we drew a comparison between two learning design standards, IMS SS and IMS LD, based on the pedagogical expressiveness and the requirements of adaptive learning authoring. From the perspective of pedagogical expressiveness, a learning standard has to fulfil three aspects: *pedagogical flexibility* in order to support various learning methods, *personalisation* related to the provision of adaptation in learning, and *completeness* to represent digital as well as non-digital resources, including learning objects, relationship between objects and activities, and workflows of learners' and teachers' activities (van Es and Koper, 2006). From this perspective, IMS LD has advantages over IMS SS.

- First, IMS LD provides various elements which have pedagogical meanings, such as learning objectives, pre-requisites, activities, roles, environments, methods, properties, and rules. IMS SS provides only predefined rules and attributes for branching learning flows.
- Second, IMS LD supports more learning methods than IMS SS. IMS SS supports only individual learning for one single learner, while IMS LD supports individual learning and also collaborative learning which involves a number of learners. IMS LD enables authors to design learning activities for different roles and one learning activity can be designed for one student, a group of students, or a class. Another advantage of IMS LD is that it supports blended learning as teachers can specify online as well as offline learning activities in one unit of learning.
- Third, IMS LD supports the learning personalisation. It is related to the support for adaptation based on learners' profiles and for sharing control among learners, teachers, and learning systems. IMS LD, on the other hand, offers wider adaptation and personalisation than IMS SS. It supports learning flow-based adaptation and also content-based adaptation and interactive problem solving-based adaptations based on learner (Kravcik et al., 2008). On the other hand, IMS SS supports learning flow branching. It appears similar

to learning flow-based adaptation provided in IMS LD. Nevertheless, unlike IMS LD, learning flow branching in IMS SS is not based on learners' characteristics.

- Fourth, IMS LD supports learner modelling by offering six types of properties. They cover all possible scopes, such as whether the value is valid for an individual or for all users, for a particular role or all roles, and for a particular course or all courses. Learners can be modelled using a combination of those properties, particularly through the use of *locpers* (local-personal) and *globpers* (global-personal) properties. A learner model can be constructed globally for all courses, or locally that is valid only for a particular course, or blended by combining global and local personal properties. In the latest approach, learner profile information which is domain independent can be recorded in global-personal properties and the learner's achievement which is domain-dependent is represented in local personal properties. Contrary to IMS LD, IMS SS does not support the learner model. Although properties are supported in IMS SS, they are not aimed to retain the learner's information; they are retained to keep values required to run or to stop particular rules - for instances *rollupObjectiveSatisfied* and *rollupProgressCompletion* attributes to control the *rollupRules* rule.

Regarding such findings, it is concluded that instead of IMS SS, IMS LD is suitable for adaptive learning.

Workspace Awareness in Asynchronous Collaborative Authoring

Awareness refers to an author's understanding of other authors' activities that provide him/her a context for future activities. Authors are required to have awareness when participating in collaborative authoring. This is not only to know what have been happening in the collaborative work, but also to understand and to respond to the changes made by other authors. Authors' awareness is important to ensure that individual activities of authors are always relevant to authoring goals. As a consequence, it is important to provide awareness information in collaborative authoring whatever the domain. There are various ways in how such information is provided, but mostly it is generated or collected, directed to one/some authors or distributed to all authors, and presented in the same workspace as authored objects or separated from the objects (Dourish and Bellotti, 1992).

There are several kinds of awareness in collaborative work for both asynchronous and synchronous forms. These include personal awareness, group awareness, social awareness, and informal awareness. Workspace awareness addresses some information which is part of all those kinds of awareness (Liccardi, 2010). Gutwin (Gutwin and Greenberg, 1996) states that workspace awareness is related to authors' understanding about other authors' presence, activity levels, actions, intentions, changes, artifacts, abilities, and expectations. Such information items were applied in synchronous collaborative work that means that information is real-time, about present occurences in authoring.

Research on workspace awareness in asynchronous collaborative authoring was then carried out with the same motivation as in synchronous collaborative authoring (Dourish, 1997). Nevertheless, when the information items of workspace awareness are applied to asynchronous collaborative authoring, the information is not about the present occurrence information anymore, but about past interaction in authoring. Workspace awareness information in asynchronous collaborative authoring is mainly about action history and artifact history (Tam and Greenberg, July 2006). Recently, a number of collaborative features have been applied in various collaborative authoring tools to gather and distribute awareness information. Some of these are communication features that gather information from authors, such as:

1. Face to face meeting (Dourish and Bellotti, 1992).
2. Note/Annotation (Weng and Gennari, 2004). For example in Collaborative Protege (Tudorache et al., 2008), in authoring tools for adaptive learning (Ghali et al., 2008), and CAWS (Liccardi, 2010).
3. Process structure with task scripts (Lowry et al., 2005).
4. Talk pages, such as Wikipedia (Kittur et al., 2009; Kittur et al., 2007).
5. Structured messaging (Dourish and Bellotti, 1992).
6. History which records provenance information (Papadopoulou, 2009; Tam and Greenberg, July 2006; Tudorache et al., 2008).

Experimental Study Methodology and Tools

This research proposes a collaborative authoring approach for adaptive learning resources for a small group of teachers to work asynchronously. It is aimed to solve the following problem:

How can teachers collaborate in authoring adaptive learning resources so that they can work together and be aware of what each has done in the authoring process?

The research is focused on studying the influence of collaborative features, *Note* and *History*, in authoring adaptive learning resources. The collaborative features should enable authors to communicate with minimum effort, so that authors do not need to identify in which thread a particular topic is being discussed.

This section discusses a quantitative experimental study with questionnaires. This is the first of two experimental studies carried out in this research, applying the following experimental question:

Sub-question 5: Do Note and History improve workspace awareness of authors in authoring adaptive learning resources in IMS LD?

The objectives are twofold: to investigate the kinds of information that are important for authors in the development of adaptive learning resources and to investigate the influence of *Note* and *History* in improving workspace awareness; both in the context of collaborative authoring of adaptive learning resources. This evaluation applied a between-group method, where participants were divided evenly into two groups. There were 44 respondents who participated in this experiment with females comprising around 36% (16 participants). They fulfilled the teaching experience requirement as they are lecturers, teaching assistants, or demonstrators in Indonesia or in the UK. We evaluated participants' profiles in terms of their experience in teaching and working with learning authoring tools and their knowledge of the three provided courses. The study aimed to test whether Group 1 and Group 2 were homogenous or not. We applied a Multivariate Analysis of Variance (MANOVA) test to participants' profiles and it produced $p=0.051$ which was greater than $\alpha=0.050$. As a conclusion, Group 1 and Group 2 are not significantly different, hence participants' profiles were not considered as a predicting variable in any case.

This evaluation used two authoring tools: ReCourse, which is an open source authoring tool that does not provide *Note* and *History*, and our prototype, an extended ReCourse called Collaborative ReCourse, that offers *Note* and *History* features.

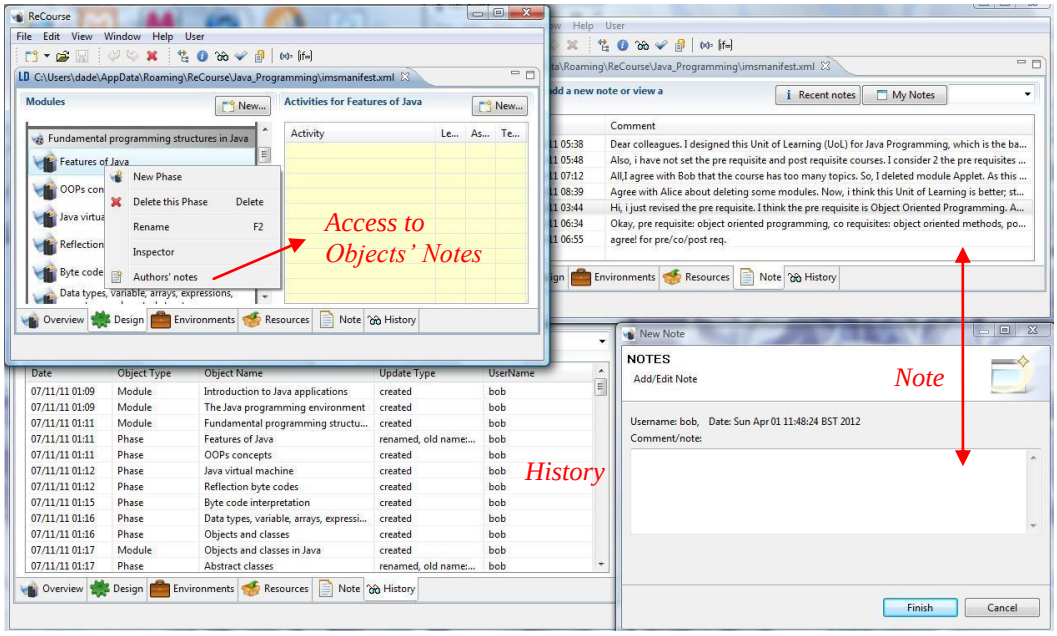

Figure 1 *Note, History, History's Note, Objects' Notes* in the prototype Collaborative ReCourse

Participants in Group 1 worked with ReCourse, while participants in Group 2 worked with Collaborative ReCourse. Each participant worked with similar Units of Learning and played a role as the fourth author in a group of four authors. The units of learning of three courses including - Biology, Web Programming, and Java Programming - were provided for both groups; Java Programming has more elements than the other courses. This evaluation applied a four-point Likert-type scale that did not allow participants to be neutral in either case. The absence of a neutral point in the questionnaires is aimed to diminish desirability bias (Garland, 1991).

Questionnaires 1 and 2 were scheduled to be administered at different times. Participants in each group were not notified about the existence of the other group that worked with a different tool and a different questionnaire. Both groups were given explanations about IMS LD. In addition, Group 1 received an overview of ReCourse and Group 2 Collaborative ReCourse and they were given sometime to interact with the tool. A questionnaire was then handed out at the end of the sessions.

The questionnaires consist of questions divided into three themes as presented in Figure 2. First, the experiement investigated authors' views about what information needs to be included in units of learning and about the availability of such information in ReCourse. Afterwards, it examined the implications of *Note* and *History* in authoring IMS LD level A. Finally, it studied the influence of *Note* and *History* on authors' awareness in authoring IMS LD level B. All themes are in the context of authoring adaptive learning resources in IMS LD. The left layer comprises authoring tasks to be performed with IMS LD elements in the middle layer and it requires authors to explore the Units of Learning included in the right layer.

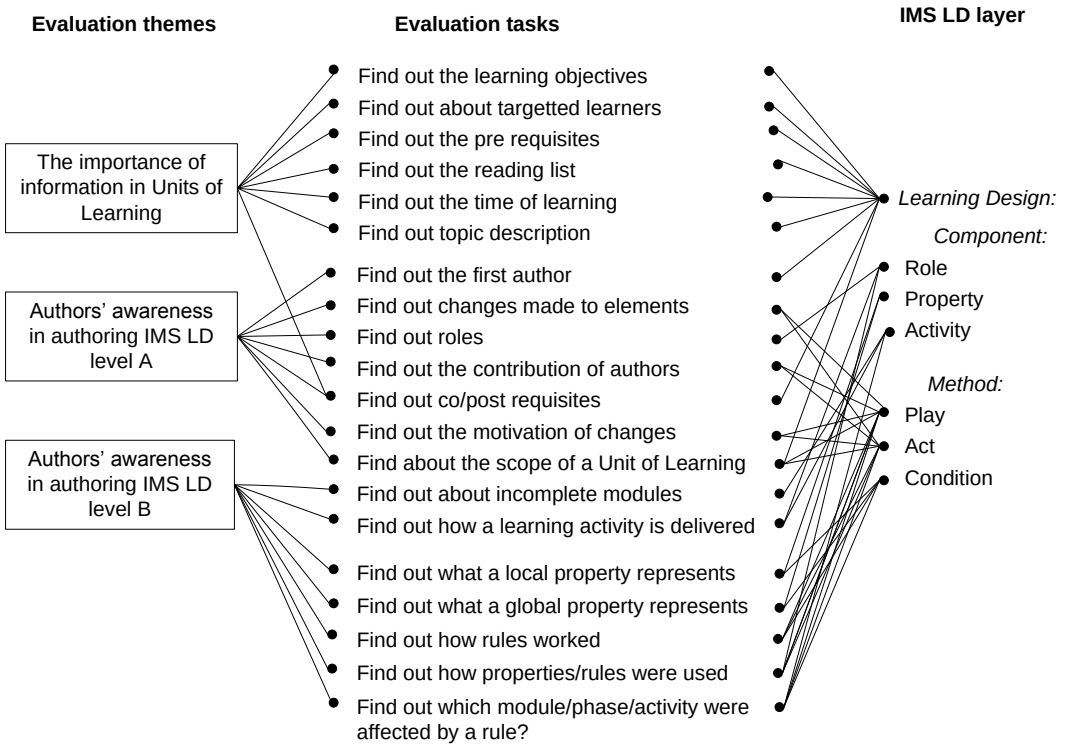

Figure 2 *Note, History, History's Note, Objects' Notes* in Collaborative ReCourse

Findings

A. Important information of a syllabus or a Unit of Learning (UoL)

This information was collected to gather users' views about the importance of information to be presented in a unit of learning. We referred to a paper about major information in a syllabus (Altman, 1992) and chose some items contained therein to be evaluated by participants. We asked all participants if information about learning objectives, targetted learners, pre/post-requisite courses, a reading list, time of learning, and the description of topics is important in units of learning. A statistical description produced a fact that participants in both groups consider that all such information items are important.

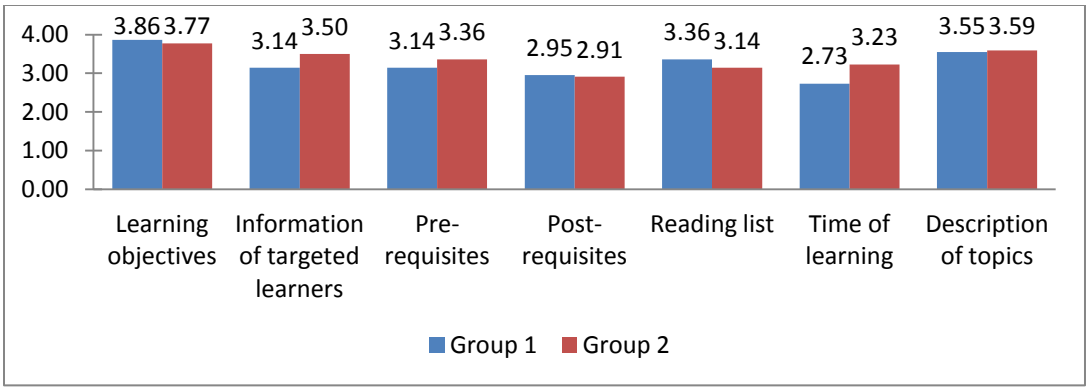

Figure 3 The means of participants' views about the importance of information on syllabus / units of learning

Of those seven information items, only learning objectives and pre-requisites are obviously provided in ReCourse. Hence, we asked participants to explore the tools, to construct some authoring tasks, and then to answer some questions; the results are presented in Figure 4. For every information item, authors who worked with Collaborative ReCourse (Group 2) found more information rather than those working with ReCourse (Group 1).

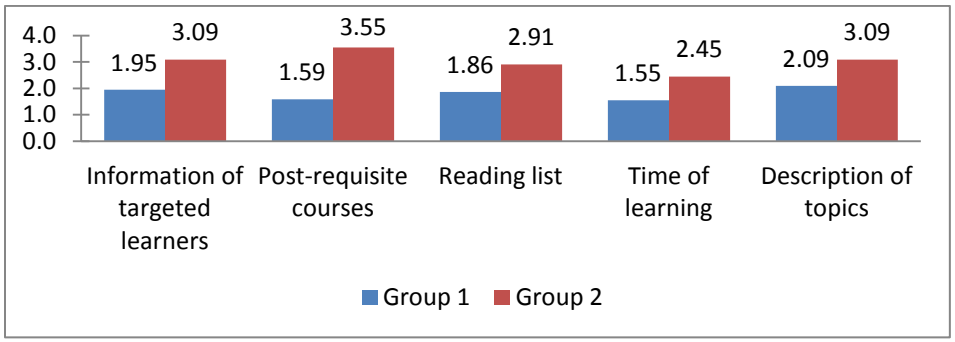

Figure 4 Participants' views of the availability of information about syllabus in ReCourse and the extended ReCourse

As we explained above, the difference in experiment environments for Group 1 and Group 2 lies in the presence or the absence of *Note* and *History*. To see if such features influenced authors' views, a MANOVA test was carried out. *Ho* of this test is that the experiments would not give a positive implication to participants. The test produced $p=0.00$ ($p<0.05$) for all parameters: Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largets Root. Hence, *Ho* was declined, and as a conclusion, *Note* and *History* give a positive implication to participants.

B. Authors' awareness in authoring IMS LD level A

In this part, the evaluation focused on collaborative authoring of IMS LD level A. When a unit of learning is authored by two or more teachers through reuse or collaborative work, more information about the development process is required. In this theme, we apply different investigation in the cases of Group 1 and Group 2. We asked participants in Group 1 to explore the units of learning and to find out whether some information about the authoring process was available. The information is about the first author who had created the units of learning, changes applied to IMS LD elements, roles, the contribution of authors, co/post-requisite courses, the motivation of changes, the scopes of units of learning, incomplete modules, and the delivery of learning activities. Afterwards, a set of questions with case examples related to the availability of information about the authoring process in ReCourse were distributed to Group 1. The aim was to raise participants' awareness of the availability or the possible insufficiency of information about a unit of learning and the authoring process itself in ReCourse. Below are two examples of the distributed questions.

- *Explore the Unit of Learning (UoL) and find out about the 'Inheritance' module. Is there sufficient information about sub-topics missing in the module, or what sub topics should be added to the module?*
- *Find out the module "Evolution, Taxonomy, and Microorganisms", then take a look phase "Darwin & Evolution". Do you think the current information, if any, about the module and the phase is sufficient to understand them?*

The results use a four-point Likert-type scale, with 4 for very sufficient, 3 for quite sufficient, 2 for not very sufficient and 1 for insufficient. The results indicate that participants did not find quite sufficient information about the authoring process in ReCourse.

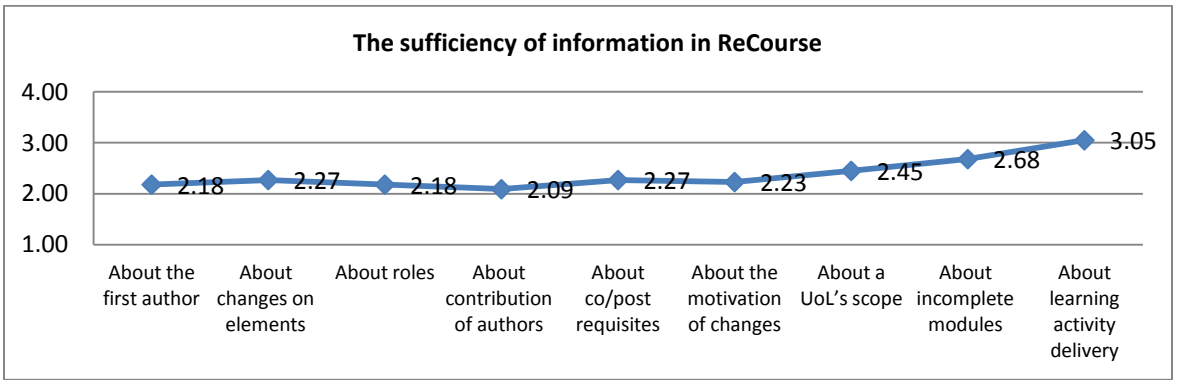

Figure 5 The availability and the sufficiency of authoring process information in ReCourse

On the other hand, we asked Group 2 participants to explore the UoL and to answer nine questions regarding such information items. Two example questions are:

- *Besides you, there are three other authors participating in creating this UoL. They are Alice, Bob, and Claudia. One of them deleted a module. Who did it, which module was deleted, and for what reasons?*
- *There was a problem on the first version of this UoL in that it had too many topics. What is the solution for that problem?*

We did not give any guidance to participants about where they could find corresponding information to answer the questions. They were free to explore the UoL to identify such information that could be found in notes written by other authors in *Note, History's Note,* or *Objects' Notes,* or perhaps in *History*. The frequencies of wrong, neutral, and correct answers are presented in Table 1.

Table 1 Group 2 participants' awareness in collaborative authoring of IMS LD level A

Information items	Wrong answers	No answers	Correct answers
About the first author	9.09%	-	90.91%
About changes on elements	-	-	100.00%
About roles	4.55%	-	95.45%
About contribution of authors	9.09%	-	90.91%
About co/post-requisites	6.82%	9.09%	84.09%
About the motivation of changes	4.55%	-	95.45%
About a UoL's scope	13.64%	-	86.36%
About incomplete modules	22.72%	4.55%	72.73%
About learning activity delivery	-	18.18%	81.82%

C. Authors' awareness in authoring IMS LD level B

In this part, the evaluation was focused on workspace awareness in collaborative authoring of IMS LD level B. The adaptation model is one component of adaptive learning resources that is considered more difficult to understand than other resources. This section describes an experiment result based on participants' understanding

of learning resources authored by other authors. For this case, we drew a comparison between Group 1 and Group 2 to see if *Note* and *History* could help authors to understand adaptation rules. All participants were required to find information in a UoL. They were free to explore the UoL that was Java Programming and we did not give any guidance to Group 2 participants over where to find notes written by former authors. Afterwards, they were required to answer some questions (the same questions were put to both groups) about what local/global properties represented, how rules worked, how properties/rules were used, and which modules/phases/activities were affected by particular properties or rules. This is one of the questions: c*heck out Rule. You will find one rule, "Rule 1". What is the objective of the rule?*

The questions used three nominal values to classify users' answers: wrong answers, no answers, and correct answers. A comparison between the number of correct answers given by Group 1 and Group 2 is described in Figure 6. In every case, Group 2 working with *Note* and *History* gave a higher precentage of correct answers than Group 1.

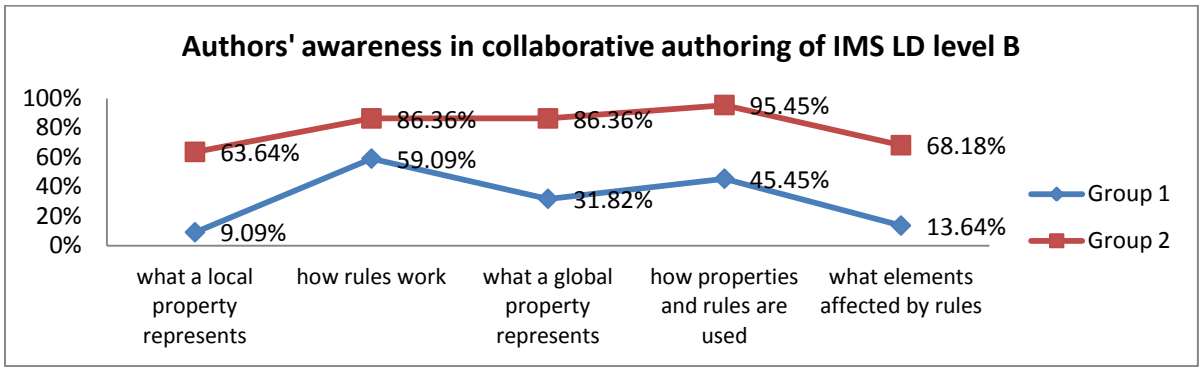

Figure 6 User awareness in collaborative authoring of IMS LD level B

A summary of participants' response for all questions is described in Figure 7. Like the previous graph, this graph also shows the positive implication of *Note* and *History* to enhance authors' awareness. The workspace awareness of Group 2 is significantly higher than that of Group 1.

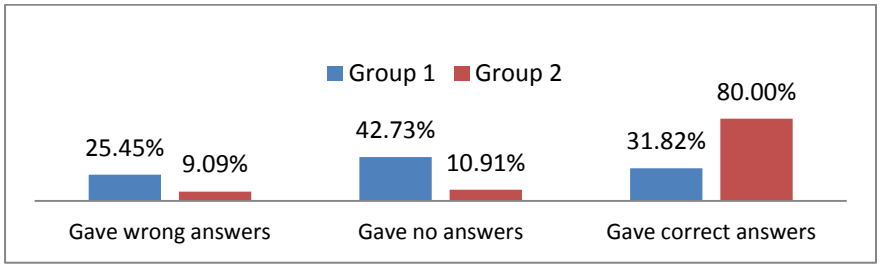

Figure 7 A summary of the evaluation of user awareness in collaborative authoring of IMS LD level B

As mentioned previously, participants' backgrounds are homogenous and in this case participants work with similar units of learning. The only difference between Group 1 and Group 2 is that Group 2 had an advantage in being able to access notes written by other authors and provenance information recorded by the tool. Therefore, it could be concluded that the presence or the absence of *Note* and *History* is the only affecting variable. We conducted a Chi Square test and it produced value 52.126 with 2 df and $p<0.001$ which means that there is a positive relationship between participants' response and the presence of *Note* and *History*.

Conclusion and Future Work

The experiment reveals findings on authoring adaptive learning resources in IMS LD. First, there is no significant difference between Group 1's profiles and Group 2's profiles. This means that participants' profiles do not influence positive views as well as negative views to ReCourse or Collaborative ReCourse. These findings

show that teachers acknowledge the importance of more information to be presented in units of learning, such as information of targeted learners, post-requisites, reading list, time of learning, and description of topics and other kinds of information about the authoring process itself, such as what changes have been made, to which elements, and by whom. The fact is that such information is not sufficient in ReCourse.

The main objective of the experiment has been achieved since the experiment has proved our hypothesis:

Authors who work with a collaborative authoring tool that provides Note and History will have higher workspace awareness than those working with an authoring tool that does not provide Note and History.

The hypothesis corresponds with previous research on workspace awareness that workspace awareness is related to authors' understanding of what has been carried out in the authoring process (Gutwin and Greenberg, 1996). This experiment divided authoring focus into two cases: authoring IMS LD level A (component) and level B (method). The division is applied to find out precisely, in which level of IMS LD authoring, *Note* and *History* could improve authors' awareness. As a result, in both cases, authors who worked with *Note* and *History* understood more about what had happened in authoring, who had edited elements, and which elements were affected by authors' work.

This experiment, however, just presents authors' awareness of what other authors have done in the authoring process. It did not aim to find out the implications of high awareness to future tasks and to the quality of artifacts in collaborative authoring of adaptive learning resources. Hence, another experiment is needed. Future work to extend this evaluation is a groupware observation and a semi-structured interview that will involve a few participants working together in collaborative authoring environments using Collaborative ReCourse. The aim is to prove the hypothesis that:

Measures of size , quality and adaptivity of the learning resources produced will be higher for authors working with an authoring tool which supports workspace awareness.

This hypothesis corresponds with former research that workspace awareness should provide a context for the future activities of authors (Gutwin and Greenberg, 1996).

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