Multimed Tools Appl (2018) 77:17437–17456
https://doi.org/10.1007/s11042-017-5312-7

Development of a visual e-learning system for supporting the semantic organization and utilization of open learning content

Pengfei Wu [1,2,3] · Shengquan Yu [1,2] · Na Ren [2] · Qi Wang [1,2] · Dan Wang [1,2]

Received: 14 March 2017 / Revised: 21 August 2017 / Accepted: 13 October 2017 /
Published online: 23 October 2017

Abstract In an open e-learning content management environment, relation metadata is of benefit to improve semantic organization and reusability of learning content. Although the suggested relations defined in the SCORM and the extended relations proposed in the past studies can describe semantic relationships, there are some new requirements of semantic organization and utilization of open learning content. Based on existing models, this paper presents an extended relation metadata model for open knowledge communities. In order to help users to author and utilize the semantic relation, the visual authoring system named web-based visual authoring system for relation metadata (WVAS-RM) in the Learning Cell Knowledge Community is designed and implemented to assist the construction and utilization of semantic relations of Learning Cells. The paper presents an empirical evaluation of the teachers' and learners' acceptance and satisfaction of the proposed system using the adapted Technology Acceptance Model and System Usability Scale. The semi-structured interviews are also carried out with participants including teachers and students. It is concluded that students and teachers feel confident and satisfied with the system.

Keywords SCORM · Relation metadata model · Visualization · Learning cell · Learning resources organization · Visual authoring system

✉ Shengquan Yu
yusq@bnu.edu.cn

[1] School of Educational Technology, Faculty of Education, Beijing Normal University, No.19 Xinjiekouwai St. Haidian district, Beijing 100875, People's Republic of China

[2] Advanced Innovation Center for Future Education, Beijing Normal University, Beijing 100875, China

[3] School of Education, Shijiazhuang University, Shijiazhuang 050035, China

1 Introduction

The reuse of learning objects is an important research topic in the learning technology community [26]. The reuse of learning objects not only saves time [3], but also facilitates learners' digital learning experiences, resulting in efficient, economic and effective learning [5, 6]. Metadata is a way to describe learning objects and can increase their reusability and interoperability. Relation metadata is of benefit to improve reusability of learning objects. Rich relations provide a method for teachers to organize learning objects effectively and for learners to locate the required learning objects easily.

Content Aggregation Model (CAM) is one part of Sharable Content Object Reference Model (SCORM). From the perspective of structure-oriented relationships, CAM defined twelve suggested values for "RELATION" metadata, inherited from IEEE Learning Object Metadata (LOM). "RELATION" metadata is mainly used to describe the features of relationships between learning resources. These relationships can help increase the opportunity of being found and improve the reusability of learning objects. In the past studies, more extended relations were proposed by other researchers to express more semantic relationships between learning resources [7, 10, 12, 20, 22, 25]. Rich relations provide a mean for learners to locate the required learning objects easily and for teachers to organize learning objects effectively.

Although the suggested relations defined in the SCORM CAM and the extended relations proposed in the past studies can describe semantic relationships between learning objects, there are some new requirements of organization and utilization of learning objects in the open knowledge communities (OKCs) [29].Firstly, in open knowledge communities, there are some types of learning objects such as instructional design, teaching reflection, research reports, research papers, research books, and so on. As for teachers, these are more important learning resources in the process of teaching and research. The existing relation models have not included these semantic relationships between learning resources. Secondly, with the rapid expansion of open learning content resources in OKCs, it is hard for teachers to organize open learning content effectively and efficiently only using the classification category. Meanwhile, it is not easy for learners to find the highly related learning resources they required [28]. Teachers and learners need to a new tool to organize and utilize the open learning content easily and effectively. How to organize the open learning content so as to improve reusability of learning objects in OKCs remains a very important research problem.

In this paper, an extended relation metadata model oriented open knowledge communities was proposed based on existing relations. A Web-based visual authoring system for relation metadata in Learning Cell Knowledge Community (LCKC) has been designed and implemented to assist construction and utilization of relations of open learning content. In this study, we have also evaluated teachers' and learners' acceptance of the proposed system with the various relations supports.

2 Literature review

2.1 Relation metadata for learning objects

LOM provided nine categories to describe educational resources. The "Relation" category defined by LOM is used to describe the relationships between learning objects. Based on LOM, CAM provides twelve values for "RELATION" metadata. Although these suggested values can describe structure-oriented relationships, they cannot express more semantic relationships between learning resources. To solve the problem, extended relations models were proposed to describe more semantic relationships between learning resources. Instruction design theory (IDT) [18] and rhetorical structure theory (RST) [14] are two major basic theories. Ullrich proposed twenty-three relationships from the perspective of IDT [25]. Based on RST, the rhetorical-didactic relations between learning objects have been proposed and utilized by researchers [7, 20, 22]. Lu et al. [12, 13] have systematically compared relations defined in IDT and RST and proposed an extension model to CAM (RST&IDT). Existing Relations Models are summarized in Table 1.

From Table 1, it is clear to find the differences and similarities among these relations models. First of all, relations defined in CAM describe structure-oriented relationships between learning objects. Some meanings expressed by these relations are general and coarse-grained such as "isbasedon", "requires". "Alternative" defined in RST expresses the same meaning with "hasformat". Secondly, relations defined in RST and IDT has two same relations –"Example" and "Illustration", which are the important relations between learning objects they thought. Finally, extended relations defined in RST&IDT were proposed from the authors' perspective and the usefulness of these relations has been tested using a web-based learning content management system. The extended relations defined in RST&IDT absorbed and drew on the relations defined in RST and IDT, and seven relations (including "Law of Nature", "Law", "Opposition", "Instance", "Continues", "Procedure", and "Restriction") were removed and two relations (including "Illustration" and"Counterexample") were re-defined according to practical requirements.

Table 1 Existing relations models

CAM	RST	RST&IDT	IDT
ispartof	Amplify/Extension	Extension	Law
haspart	Deepen/Intensification	Deepen	Law of Nature
isversionof	Illustration	Illustration	Illustration
hasversion	Example	Example	Example
isformatof	Instance	Definition	Definition
hasformat	Restriction	Fact	Fact
references	Continues	Theorem	Theorem
isreferencesby	Opposition	Process	Process
isbasedon	Alternative	Guideline	Policy
isbasisfor		Counterexample	Counterexample
requires		Evidence	Evidence
isrequiredby		Proof	Proof
		Demonstration	Demonstration
		Explanation	Explanation
		Introduction	Introduction
		Conclusion	Conclusion
		Remark	Remark
			Procedure
			Interactivity
			Exploration
			Real World Problem
			Invitation
			Exercise

2.2 Knowledge visualization in E-learning

According to the general rule of human information acquisition, the graphics can be more intuitive and easier to understand the connection and nature of data. People are more inclined to get information from the graphics. Knowledge visualization is a field of study, in which visual formats is used to represent knowledge to improve the transfer and creation of knowledge [2]. It aims at supporting cognitive processes in generating, representing, structuring retrieving sharing and using knowledge [23]. Knowledge visualization has been widely used in various learning environments to augment cognition, assist meta-cognition, support knowledge building and facilitate thinking and scientific inquiries [27].

Knowledge visualization can express the meaningful and structured information units using visual images with explicit and semantic relationships networks. Knowledge visualization connects users and resources more effectively by presenting information resources for users within a specific knowledge structure [9]. Using a knowledge visualization approach can help learners to scaffold conceptual understanding, improve memorization and facilitate access to learning resources, and support individual and social learning [27]. Utilizing visual knowledge authoring tools is an easier way for teachers to organize learning resources and manage knowledge.

3 An extended relation metadata model for OKCs

Users and learning resources are two core elements in OKCs. There are two kinds of users in OKCs—teachers and students. They require different organizations of learning resources. On one hand, learning resources should be organized for assisting learning, since a large number of scattered and disordered learning resources would increase learners' cognitive load and confuse them. On the other hand, learning resources organization should meet the practical requirements of teaching. Learning resources contain different learning contents. Different learning contents play different roles in the learning process. For example, at the beginning of new lesson, teachers need to presents the prior knowledge firstly and enable learners to review previous knowledge. Based on the present knowledge, it is easier to establish connection and promote meaningful learning for students. In addition, training and research activities are the important parts in the process of development of teachers. Meeting the need of learning resources organization for teachers is also very urgent.

As discussed previously, there are some models such as SCORM CAM model and other models based on instructional design theory or rhetorical structure theory. Although these models can describe the relationships between learning objects, they are designed from only a single dimension without consideration of the actual and various needs of users in OKCs. On the basis of the above investigation on the relationships between learning resources, we proposed an extended relation metadata model for OKCs, which could be divided into two dimensions: content structure oriented relations (CSR) and instruction and research oriented relations (IRR), as shown in Fig. 1.

IRR is divided into two sub-categories: Instruction Relations and Research Relations. Instruction Relations are used to express the relations between learning resources from the instructional design perspective while Research Relations from instructional research perspective. Most of Instruction Relations are adopted from RST&IDT because the usefulness of these relations proposed in RST&IDT was tested by the past studies. As "Process" is similar with

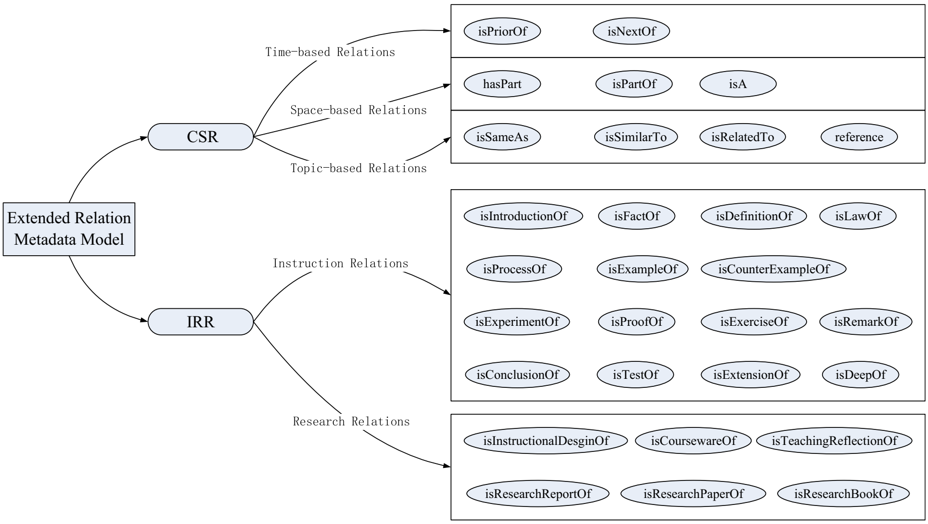

Fig. 1 An extended relation metadata model for OKCs

"Guideline" and "Proof" is similar with "Evidence" and "Demonstration", only "Process" and "Proof" is retained. As "Explanation" is the parent class of "Introduction", "Conclusion" and "Remark", so "Explanation" is removed. "Illustration" is the parent class of "Example", so "Illustration" is removed. "isExperimentOf", "isExerciseOf" and "isTestOf" are new relationships to express the relations between learning resources. Research Relations consist of six new relationships: "isInstructionalDesginOf", "isCoursewareOf", "isTeachingReflectionOf", "isResearchReportOf", "isResearchPaperOf" and "isResearchBookOf". Research Relations aim at providing relations for teachers to organize their learning resources for instructional research.

In order to avoid the ambiguity of the definitions of relations in the open knowledge communities, Chinese Name of relations are offered, as shown in Table 2. In the extended relation metadata model for OKCs, "isRelatedTo" and "isSimilarTo" are two new relations to express the content structure relationships between learning resources in some topic. "isExperimentOf", "isExerciseOf" and "isTestOf" are new relationships to express the instruction relations between learning resources. "isInstructionalDesginOf", "isCoursewareOf", "isTeachingReflectionOf", "isResearchReportOf", "isResearchPaperOf" and "isResearchBookOf" are new relationships to provide relations for teachers to organize their learning resources for instructional research. Other relationships in the extended relation metadata model for OKCs are reused from the existing models such as RST, CAM and IDT.

4 A web-based visual authoring system for relation metadata

In order to support the process of relation metadata construction and utilization of open learning content, a web-based visual authoring system for relation metadata (WVAS-RM) is proposed and developed in this paper. The design goal of the WVAS-RM is to make a visual organization and utilization of the learning resources in the OKCs, and to provide more intuitive and clear relationships of learning resources. In view of the above goal, this paper

Table 2 An extended relation metadata model for OKCs

English Name	Chinese Name	Source	English Name	Chinese Name	Source
isPriorOf	是前驱	RST	isCounterExampleOf	是反例	RST&IDT
isNextOf	是后继	RST	isConclusionOf	是总结	RST&IDT
hasPart	包含	CAM	isRemarkOf	是评论	RST&IDT
isPartOf	属于	CAM	isProofOf	是证据	RST&IDT
isA	继承	CAM	isExerciseOf	是练习	New
isSameAs	等价	CAM&RST	isExperimentOf	是实验	New
isRelatedTo	相关	New	isTestOf	是试题	New
isSimilarTo	相似	New	isExtensionOf	是拓展	RST&IDT
reference	引用	CAM	isDeepOf	是深化	RST&IDT
isIntroductionOf	是引言	RST&IDT	isInstructionalDesginOf	是教学设计	New
isFactOf	是事实	RST&IDT	isCoursewareOf	是教学课件	New
isDefinitionOf	是定义	RST&IDT	isTeachingReflectionOf	是教学反思	New
isLawOf	是理论	RST&IDT	isResearchReportOf	是研究报告	New
isProcessOf	是原理	RST&IDT	isResearchPaperOf	是研究论文	New
isExampleOf	是例子	RST&IDT	isResearchBookOf	是著作	New

considers that the functional requirements of the construction platform of the visual authoring system should include the following two aspects: visual relationship editing for teachers to organize and manage learning resources and visual results presenting for students to learn via a visual knowledge network map. WVAS-RM provides teachers with a visual authoring environment for creating, editing and managing the semantic relations of learning resources. It allows teachers to use the mouse to drag to edit the relationship, including relationship adding, deleting and modification. It also allows teachers to search the relevant learning resource nodes to add. Teachers drag and drop learning resource nodes in the authoring interface and then join the learning resource nodes together to produce a visual learning knowledge network map. WVAS-RM also provides students with a visual learning environment for viewing and learning the semantic relations and knowledge content of learning resources. It allows students to use the mouse to view and navigate the relationships between learning resources. Students may click the learning resource node to learn the knowledge content via the visual learning knowledge network map created by teachers.

LCKC is an open and online knowledge community constructed base on Learning Cell [30]. It supports collaborative knowledge authoring, knowledge aggregation, evolution, multiple-level interaction, and multidimensional communication. Its main functional modules are the Learning Cell (LC), the Knowledge Group (KG), the Knowledge Cloud (KC), the Learning Tool (LT), the Personal Space (PS) and the Learning Community (LC). Since it was inaugurated in May 2011, 23,597 users have registered, 79,748 Learning Cell s have been created, and 15,063 knowledge groups have been formed (as of Nov 30, 2016). LCKC can be accessed at http://lcell.bnu.edu.cn. The web-based visual authoring system for relation metadata is a sub system designed, developed and implemented in LCKC.

4.1 System architecture

The architecture of the proposed system is shown in Fig. 2, which is composed of five modules, namely a Student Visual UI module, a Teacher Visual UI module, a Visual Relationship Demonstration (VRD) module, a Visual Relationship Authoring (VRA) module and a Resources & Relations database module.

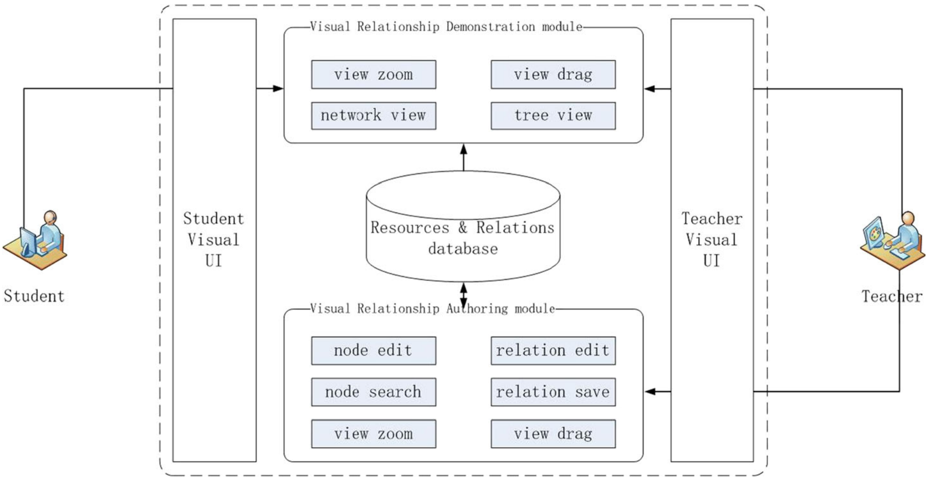

Fig. 2 System architecture of the web-based visual relation metadata authoring system

The Student Visual UI module provides a visual and graphic user interface for student users. It demonstrates different visual relationships between learning resources for learners to acquire the semantic relationships and connections among learning resources.

The Teacher Visual UI module also provides a visual and graphic user interface for teacher users. It offers visual relationships authoring windows for teachers to add, edit, and delete relationships between learning resources.

The VRD module contains a view zoom component, a view drag component, a network view component, and a tree view component. These components are used to deal with the users' interactive operating information.

The VRA module contains a node edit component, a relation edit component, a node search component, a relation saving component, a view zoom component, and a view drag component. These components are used to deal with the teachers' interactive operating information to support visual relationship authoring.

The Resources & Relations database module aims at storing the relation metadata of learning resources in the background. It also stores the other metadata of learning resources such as title, abstract, and so on.

4.2 Design of functionality

Figure 3 shows an example of the window of Teacher Visual UI for authoring relationships between Learning Cells in a knowledge group. Teachers can organize different learning resources such as Learning Cells through the Teacher Visual UI. Operating Buttons located at the left and right bottom of the Teacher Visual UI provide view moving and zooming for teachers' authoring process. In the upper left of the window, it is the menu for authoring relations. Teachers click the menu to start editing relationships.

Figure 4 shows an example of the window of the VRA module for relationship authoring of a Learning Cell. In the upper left of the window, there are three menus: Add node (knowledge node adding), Add relation (semantic relationship adding), and Delete the selected (the selected node deleting). The workflow of the VRA module is described below. First, when a teacher selects a Learning Cell, its font turns bold. Then, after dragging the selected Learning

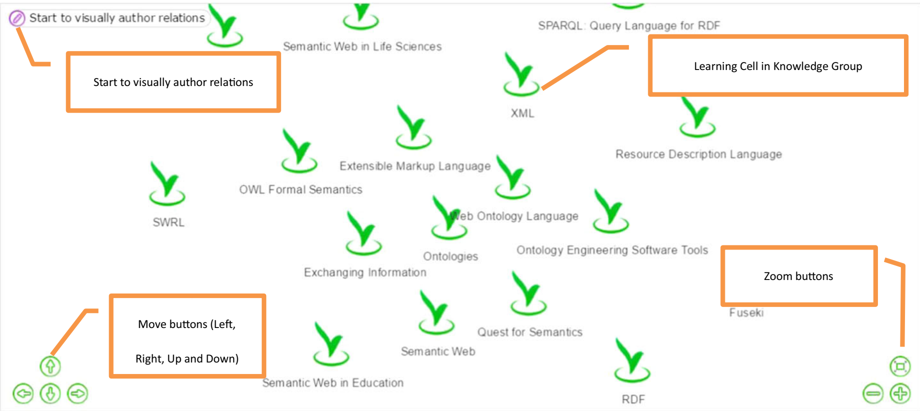

Fig. 3 Window of the Teacher Visual UI

Cell to another Learning Cell, a window appears demonstrating the defined relationships proposed in the previous chapter of "An Extended Relation Metadata Model for OKCs".

The window of the defined relations is shown in Fig. 5. The defined relations are divided into two groups: content structure oriented relations and instruction and research oriented relations. Teacher may select a relationship to describe the relation between the two Learning Cells. The relationship can be saved by clicking the corresponding button. The constructed relationships are visualized on the right-hand side of the window (as shown in Fig. 5).

In addition, teachers can add new knowledge nodes to edit their relationships by search queries. The node search component is in charge of this work. Figure 6 shows an example of node searching. When a teacher inputs the keywords into the search box, the node search component will search the related learning resources in the back Resources & Relations database and return the most relevant results. Then, teacher can select the required one or more learning resources to add.

The VRD module is designed to deal with the interactive data from the Student Visual UI to make the demonstration view move up, move down, move left, move right, zoom in, and zoom out. In addition, it also supports the function of dragging demonstration view using mouse for students. Moreover, a tree view component is designed to display the tree of

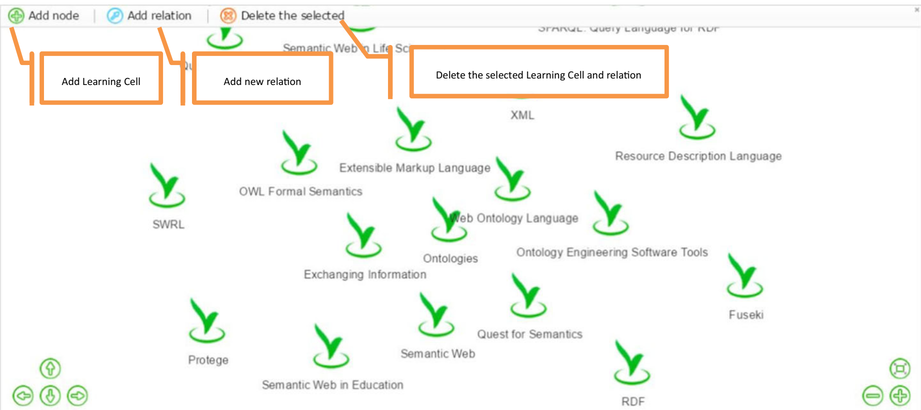

Fig. 4 An example of relationship authoring

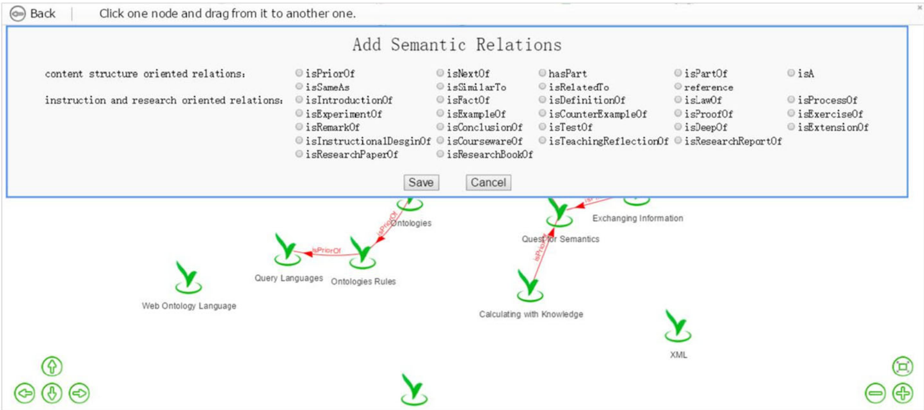

Fig. 5 Window of the defined relations

relationships between learning resources. Figure 7 shows an example of the window of Student Visual UI for demonstrating relationships between Learning Cells in a Knowledge Group. It illustrates clear graphic relationships and connections between Learning Cells for students in the Knowledge Group. Students are guided by the connections and may find the logic semantic relations among different learning resources.

4.3 System implementation

Taking into account the adaptability as well as versatility of the system, blended implement technologies are employed in the WVAS-RM. For instance, the server uses Tomcat as the Web server, the MySQL database as the data storage. The J2EE technology realizes the background service control processing, Java Server Pages (JSP) realizes Teacher Visual UI module and Student Visual UI module. The VRD module and VRA module are based on the open source visualization Vis.js[1] in which HTML5 canvas technology is employed. The data exchange between each modules using the standard JSON format data and JQuery.

5 Evaluation

An evaluation was conducted in order to collect information about satisfaction and impact of our proposed system. On one hand, we evaluated teachers' and students' perceptions and reactions towards the system and its visual relation authoring related functions, in order to find whether they were acceptable and satisfactory. On the other hand, further explorations into the effects of our system on teaching and learning were conducted.

5.1 Experiment design

In this study, the participants were divided into two groups: a teacher group and a student group. 12 undergraduate students and 12 teachers from Beijing Normal University were invited to participate in the experiment. They were all skilled users of LCKC before

[1] vis.js - A dynamic, browser based visualization library. http://visjs.org/.

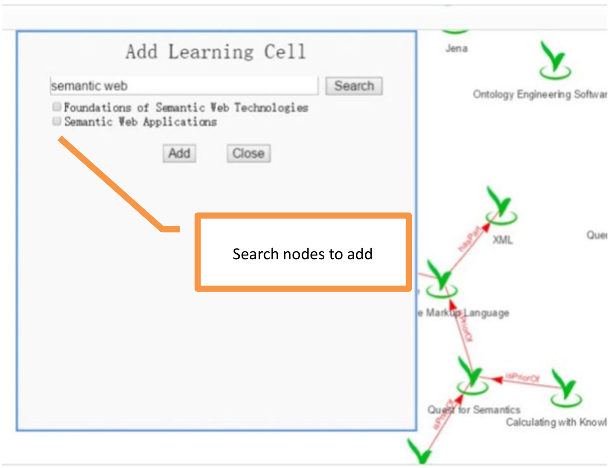

Fig. 6 An example of node searching

participating in this study. But neither teachers nor students had experience with the WVAS-RM system.

The study aims to evaluate the satisfaction and acceptance of the WVAS-RM for both students and teachers. System Usability Scale (SUS) [1] and Technology Acceptance Model (TAM) [4] have been applied as effective tools for predicting user satisfaction and acceptance of e-learning systems in related works [11, 17, 19, 21]. The questionnaire is comprised of 4 aspects: perceived easy to use (PEU), perceived usefulness (PU), attitude toward use (AU) and intention to use (IU). The items measuring the four aspects were adapted from the SUS and TAM. They were customized to the context of the WVAS-RM environment to evaluate the satisfaction and acceptance of the system in this study. The results were measured by the 5-point Likert scale (1 represented "strongly disagree" and 5 represented "strongly agree"). The results of the questionnaires were accessed using a professional survey platform (http://www.sojump.com/).The questionnaire was designed to find out the teachers' and learners' satisfaction and acceptance of this system.

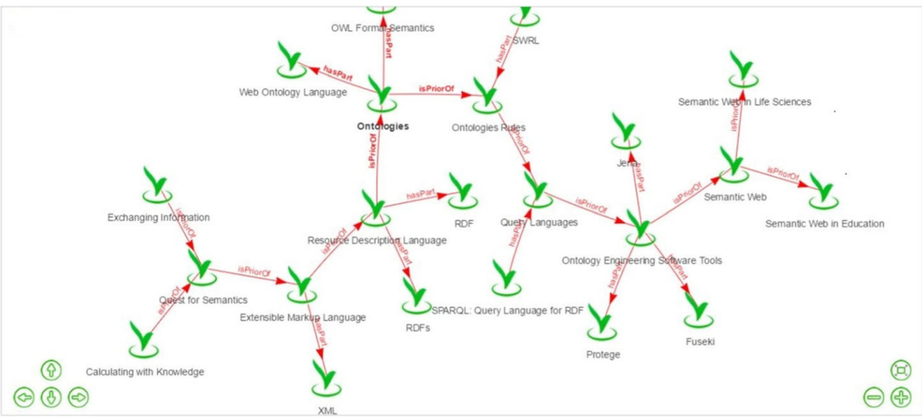

Fig. 7 An example of Student Visual UI

The experiment process was implemented in the following steps shown as Fig. 8. Firstly, instrumentation of the evaluation tool was established. Secondly, before the teachers and students started to use the system, an introduction to the proposed system was conducted. Thirdly, teachers and students completed their tasks. Each teacher created one Knowledge Group (KG) about the learning subject of "Web Technology Development" in LCKC and then used the system to author relationships between Learning Cells (LCs) in the created KG. After that, students used the system to learn in KGs about the learning subject of "Web Technology Development" created by teachers. Each student was required to learn ten KGs created by teachers. Fourthly, after using the system, a questionnaire was used to collect the teachers' and students' feedback. This measured the teachers' and students' perceptions concerning perceived easy to sue, perceived usefulness, attitude toward use and intention to use. Finally, qualitative exploratory data analysis was implemented. Interviews were conducted to collect qualitative feedback from the teachers' and students' regarding their comments on the system and perceived effectiveness and efficiency of the system on teaching and learning.

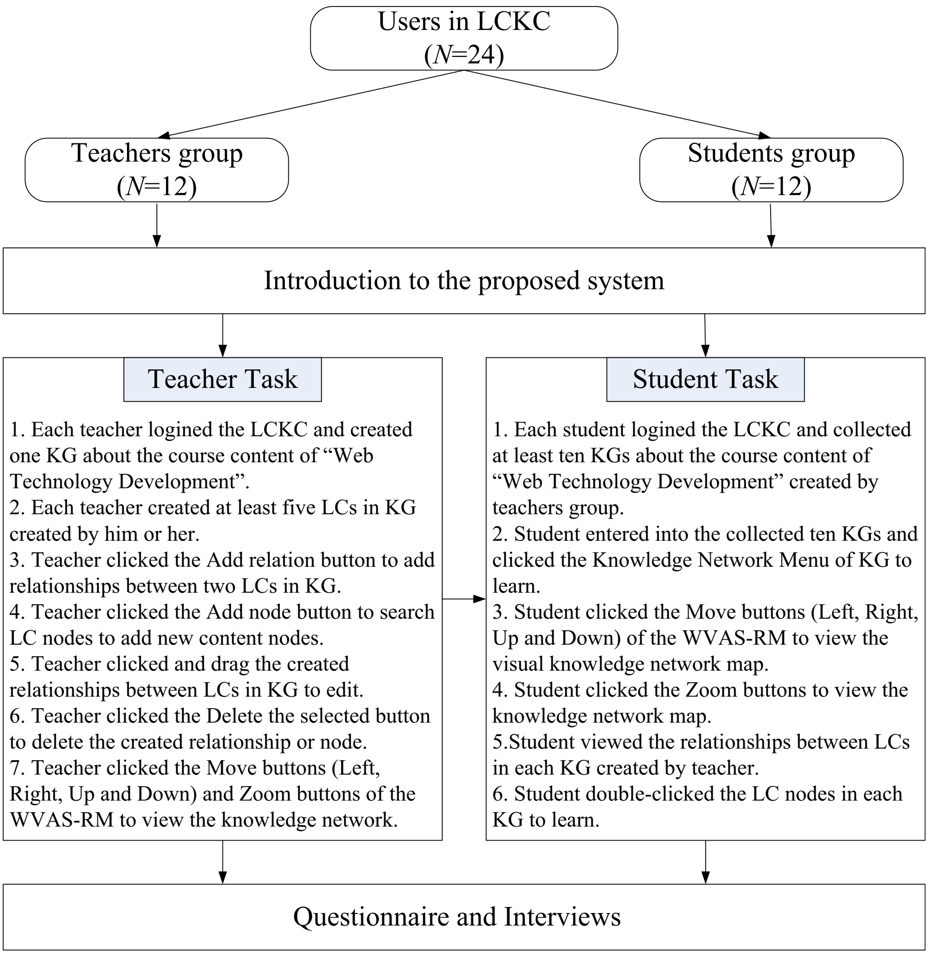

Fig. 8 Experiment process

5.2 Questionnaire results

We obtained the responses to the survey in the section of the questionnaire. The reliability coefficient of the questionnaire for teachers was calculated as 0.946. The reliability coefficient of the questionnaire for students was calculated as 0.739. It showed good reliability in internal consistency.

Table 3 shows the mean values and standard deviation of the responses for the statements regarding participants' acceptance and perceptions of our proposed system's ease of use (No.1-No.6), usefulness (No.7- No.12), attitude (No.13- No.18), and intention (No.19- No.20).

First, we describe the data collected from the teacher survey, which corresponds to the mean values of the left side of Table 3. It could firstly be observed that teachers agreed that using the proposed system in order to author relationships was not difficult (No.1–4.00).Likewise, teachers strongly agreed that they spent less time to know how to use the system (No.2–4.25). In addition, they strongly agreed that the visual construction of relationships was clear and understandable (No.3–4.33). Furthermore, they soon knew how to use the system by means of an interactive graphical interface (No.4–4.25), and they found it easy to interact with (No.5–4.08). In general, it was easy for teachers to use the system to author the relationships (No.6–4.08).

According to the usefulness of the system for managing teaching materials, most of teachers agreed that the system enabled them to achieve the diversification of forms of association of teaching materials (No.7–3.92) and it was helpful for them to organize learning materials (No.8–3.92). Also, most of the teacher participants agreed that the system was able to improve their teaching and productivity (No.9–3.83). Most of the teachers really agreed that the system enhanced their effectiveness and provided a good approach to managing teaching

Table 3 The mean score and standard deviation of each item of the questionnaire

No.	Factor	Teachers			Students		
		Mean	SD	N	Mean	SD	N
1.	PEU	4.00	.603	12	3.92	.515	12
2.	PEU	4.25	.622	12	4.17	.577	12
3.	PEU	4.33	.651	12	3.67	1.073	12
4.	PEU	4.25	.622	12	4.33	.651	12
5.	PEU	4.08	.793	12	4.25	.622	12
6.	PEU	4.08	.793	12	4.08	.669	12
7.	PU	3.92	1.165	12	3.92	1.240	12
8.	PU	3.92	.900	12	4.67	.492	12
9.	PU	3.83	.718	12	3.92	.669	12
10.	PU	4.00	1.044	12	4.00	.739	12
11.	PU	4.00	.603	12	4.00	.853	12
12.	PU	4.17	.577	12	3.75	.622	12
13.	AU	4.25	.452	12	4.17	.389	12
14.	AU	4.25	.965	12	4.42	.669	12
15.	AU	4.00	.739	12	4.17	.577	12
16.	AU	4.00	.603	12	3.58	.515	12
17.	AU	4.00	.603	12	4.50	.522	12
18.	AU	4.08	.515	12	3.92	.669	12
19.	IU	4.08	.515	12	3.75	.754	12
20.	IU	3.92	.793	12	4.00	.739	12

materials (No.10–4.00 and No.11–4.00). In general, it could be observed that faculty participants found the system useful and suitable when managing teaching materials (No.12–4.17).

As for teacher's attitude towards the system, they strongly wanted to use the visual system to organize the teaching materials (No.13–4.25). More detailed, teachers participants really agreed that using visual relationship authoring, resource organization was more intuitive and interesting (No.14–4.25). They really agreed that they wanted to use the system to show the teaching resources and carry out the construction of relationships (No.15–4.00 and No.16–4.00). They also really agreed that they would like to use the system to organize the teaching resources and manage the construction of relationships (No.17–4.00 and No.18–4.08).

As for intention to the system, teacher participants really agreed that they would continue to use the visual system to organize the teaching materials in the future (No.19–4.08) and most of them would recommend to other teachers to use the system (No.20–3.92).

Next we describe the data collected from the student survey, which corresponds to the mean values on the right side of Table 3. It could be observed that student participants agreed that using the proposed system to learn was not difficult (No.1–3.92). Student participants strongly agreed that they spent less time to know how to use the system (No.2–4.17). In addition, most of them agreed that the visual relationships are clear and understandable (No.3–3.67). The reason could be that they interacted with the system by the means of a new advanced graphical and interactive interface. Furthermore, they strongly agreed that they soon knew how to use the system by the means of an interactive graphical interface (No.4–4.33). They also strongly agreed that the system was easy to interact with (No.5–4.25). In general, it was easy for students to use the system to study (No.6–4.08).

According to the usefulness of the system for learning, most of students agreed that the system could show the diverse forms of the associations of learning materials for them(No.7–3.92) and it was most helpful for them to find relationships among different learning materials (No.8–4.67). Also, most of the student participants agreed that the system was able to improve their learning and productivity (No.9–3.92). The student participants agreed that the system helped them understand the learning content and provided a good approach to demonstrating learning materials (No.10–4.00 and No.11–4.00). In general, it could be observed that most of student participants found the system useful for learning materials display and helpful for learning (No.12–3.75).

As for student's attitude towards the system, compared with the traditional way, they really wanted to use the visual system to study (No.13–4.17). More in detail, student participants strongly agreed that using visual relationship of resource organization to study was more intuitive and interesting (No.14–4.42). Most of student participants agreed that they wanted to use the system to demonstrate the learning materials and study (No.15–4.17 and No.16–3.58). They also strongly agreed that they would like to use the system to demonstrate the learning materials (No.17–4.50). They also agreed that they would like to use the system to study (No.18–3.92).

As for the intention to the system, most of student participants agreed that they would continue to use the visual system to study in the future (No.19–3.75). They agreed that they would recommend the system to other students (No.20–4.00).

Table 4 shows the results of the mean score and standard deviation of each part of the questionnaire. For PEU of the teachers, the mean was 4.16, showing that the teachers found the WVAS-RM easy and intuitive. For PU of the teachers, the mean was 3.97, showing that the teachers accepted the WVAS-RM as a useful visual system. For AU, the mean was 4.09, showing that the teachers were highly satisfied with their instructional experience in the

Table 4 The mean score and standard deviation of each part of the questionnaire

	Teachers				Students		
	Mean	SD	N		Mean	SD	N
PEU	4.16	.502	12	PEU	4.06	.404	12
PU	3.97	.630	12	PU	4.04	.326	12
AU	4.09	.479	12	AU	4.12	.349	12
IU	4.00	.564	12	IU	3.87	.527	12

WVAS-RM. For IU, the mean was 4.00, showing that the teachers affirmed that they would use the WVAS-RM in others courses. For PEU of the students, the mean was 4.06, showing that the students also found the WVAS-RM easy. For PU of the students, the mean was 4.04, showing that the students accepted the WVAS-RM as a useful learning system. For AU, the mean was 4.12, showing that the students were highly satisfied with their learning experience in the WVAS-RM. For IU, the mean was 3.87, showing that the students would use the WVAS-RM in the future. In summary, the teachers and students found the new visual e-learning system acceptable and were satisfied in their teaching and learning process.

Meanwhile, the Pearson correlation coefficient was used to analyze the correlations between PEU, PU, AU and IU with results presented in Table 5.

As for teachers, it could firstly be observed that PU was significantly related to PEU, AU and IU. This indicates that, the useful services of organizing and managing learning materials could be provided by the WVAS-RM, and thus more teachers would be willing to use it. In addition, PEU was significantly related to AU and had higher correlation than PU and IU. It means, the easier operation, the higher the attitude would be. As for students, it could be found that PEU was related to PU and had higher correlation than AU and IU. It indicates that, the easier operation enabled students perceive usefulness. In addition, PU was related to IU and AU. This indicates that, the WVAS-RM provided the useful learning materials display and was helpful for students' learning, and thus more students would be willing to use it. Surprisingly, AU had negative correlation with IU based on these results. After the descriptive analysis and Pearson coefficient analysis, the semi-structured interviews data were also analyzed for further evaluation.

5.3 Findings from the interviews

Four participants including two teachers and two students were interviewed individually to give their comments on the WVAS-RM and to describe the impact of the

Table 5 Pearson correlation matrix between the variables

	Teachers				Students			
	PEU	PU	AU	IU	PEU	PU	AU	IU
PEU	1				1			
PU	.852**	1			.549	1		
AU	.891**	.937**	1		.112	.393	1	
IU	.829**	.830**	.897**	1	.328	.473	−.195	1

**Indicates correlations significant at the 0.01 level system on their teaching and learning. Teachers and students were encouraged to discuss and remark any issue that they felt relevant. The findings from the interview were reported as follows.

All the participants expressed their clear satisfaction with the system from the two perspectives. As one teacher said, "The visual relationship authoring system is very new for me. The system provides a very simple and visual drag way to build resource associations. The direction of the relationship is more flexible, especially for courses with the more related resources. The system is very practical". As the other teacher remarked, "The visual relationship authoring system is very useful for the construction of multidimensional relations of learning resources. The visualization of the relationships can be clearly displayed. I spend less time organizing resources and designing teaching with the help of relationships between learning resources". One student said: "Visual knowledge network is useful for me to study the web development technology, especially when they don't know much about content knowledge. With the relationship of the visual knowledge network diagram to demonstrate the relationships between knowledge content, I get a bracket for my learning." The other student said: "Using dynamic visualization of the knowledge network, I can quickly understand the logic of the relationship between technical knowledge to facilitate my study." In relation to other functions, most participants commented that it was very convenient to browse knowledge network maps and access relevant learning resources by clicking the knowledge nodes they wanted to learn.

Meanwhile, the participants also mentioned some limitations of the system. As one teacher said, "Sometimes when knowledge network nodes are too more, texts of relationships are covered by each other". They also expected more flexible self-defined relationships of learning materials. As for students, they suggested the visual knowledge network maps could be stopped shaking as soon as possible in addition to getting more learning information from other students.

The data obtained from the interviews indicated that teachers and students perceived effectiveness and efficiency of the system on teaching and learning. The WVAS-RM had a positive impact on the teaching and learning process from the point of view of the student and teacher participants. It also suggested the partial poor usability of the WVAS-RM that must be improved and optimized.

6 Discussions

In this study, we developed a visual e-learning system named WVAS-RM. The purpose was not only to help teachers visually organize and manage the open learning content, but also to help students facilitate learning through the visual learning resources map.

From a resource relation model perspective, an extended relation metadata model for OKCs is to express semantic relationships between open learning content. In one hand, the semantic relationships extracted from the existing models such as RST, CAM and IDT are reused in open learning environment. In the other hand, new relationships are added to express the content structure relations, instruction relations and research relations for various needs of teachers and students in OKCs. These semantic relationships can not only provide an explicit approach to formal and sharable representation of open learning content, but also future help increase the opportunity of being found, improve the reusability and are benefit for building more machine-understandable learning resources network [24]. In a web multimedia context, as attributes of the linking entities semantic relations are of benefit in the process of semantic annotation with context-related relation metadata [15].

Compared with the common web-based e-learning system such as Moodle, Sakai and Blackboard, the WVAS-RM architecture was designed based on the theory of knowledge visualization and the extended relation metadata model for OKCs. This architecture is what principally distinguishes WVAS-RM from other web-based e-learning system by providing teachers and students with a visual authoring environment and a visual learning environment. WVAS-RM provides teachers and students with visual relationships authoring and demonstration functions for supporting the semantic organization and utilization of open learning content. The Teacher Visual UI and Student Visual UI provide visual and interactive graphic user interfaces for teacher and student users. Knowledge visualization approach can not only facilitate teachers to organize and manage learning content, but also help learners to scaffold conceptual understanding, improve memorization and facilitate access to learning resources [27].The students were provided with a visual learning resources map interface that could lead learners to locate learning materials and understand the knowledge structure in more efficient ways. This result can be used to build a visual semantic knowledge map interface into the e-learning environment.

From a visual e-learning system usability perspective, the experimental results show that the score obtained via the adapted Technology Acceptance Model and System Usability Scale questionnaire is not a sufficient measure to reveal the true acceptance and satisfaction of teachers and students for using the visual e-learning system. The results of this study are consistent with those obtained by Harrati et al. [8]. Interviews were also used for further evaluation. Based on the attained scores and interview data, teachers' and students' perceptions of visual e-learning systems tended to be positive. Visual relationships authoring windows help teachers organize and manage relationships between learning resources. The visual relationships between learning resources help learners acquire the semantic relationships and connections among learning resources. They believed that such visual system could enhance teaching and learning effectiveness. As for students, one interesting observation is that the effect of attitude on the intention to use the system is weak. One of the possible explanations is that they were required to learn using the visual e-learning system by teachers. The same argument has been confirmed in [16] that a positive attitude may not generate a high intention to use if the students are not required to use the e-learning system. In addition, knowledge network map combined with social network map may be better for enhancing students' learning experience. The visual e-learning system will be needed to modify and update to future satisfy the requirement of teachers and students.

7 Conclusions

Relationships between learning resources are very important for organization and utilization. Firstly, based on existing relations, we proposed an extended relation metadata model for open knowledge communities. Secondly, a web-based visual authoring system for relation metadata named WVAS-RM in LCKC was developed and implemented to assist construction and utilization of semantic relations. Thirdly, this study also evaluated teacher and learners' acceptance and satisfaction of the proposed system. The TAM and SUS were adapted to analyze the acceptance and satisfaction to use the system, in terms of the ease of use, usefulness, attitude and intention, for both student and teacher participants. A questionnaire was designed and used to measure the willingness of adoption or usage of the proposed system. Experiments were conducted on online courses in LCKC for undergraduate students and teachers from Beijing Normal University. According to the data collected from the surveys, the student and teacher participants who evaluated the system found it significantly easy to use and useful for the purpose of visual management and demonstration of open learning resources. In this sense, different results were described and more detailed conclusions were given in the corresponding sections for each statement. Therefore, the system had a positive impact on the instructional resource organization and learning process from the point of view of the student and teacher participants. The experimental results showed that the participants found the system significantly easy to use, and it proved useful for their purposes. It was also concluded that participants were confident with the system. Future work is to make the learning resource recommendation using the relation metadata to further improve the learning effectiveness and achievement.

Acknowledgements This research was funded by the project "the Research on Internet plus Educational System" (Project No.16JZD043).

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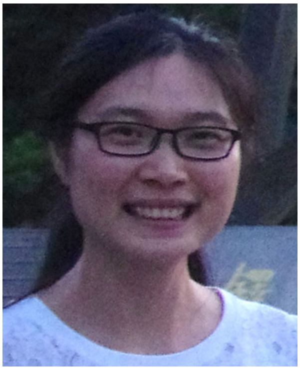
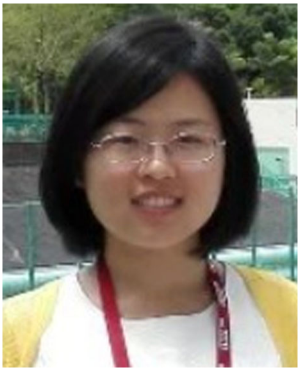
Pengfei Wu is a PhD student in Educational Technology from Beijing Normal University. He is also a teacher in School of Education of Shijiazhuang University. His primary research interests include e-Learning System and Knowledge Organization.

Dr. Shengquan Yu is a professor of Educational Technology in School of Educational Technology, Faculty of Education at Beijing Normal University. He is also the leader of the Advanced Innovation Center for Future Education at Beijing Normal University. His primary research interests include Mobile Learning, Learning Resources Organization, e-Learning System and Information Teaching.



Na Ren is a staff in Beijing Normal University. Her research interests include Mobile Learning and e-Learning.

Qi Wang is a PhD student in Educational Technology from Beijing Normal University. His research interests include Learning Resources Organization, e-Learning System and Semantic Web.



Dan Wang is a PhD student in Educational Technology from Beijing Normal University. Her research interests include e-Learning System and Data Mining.