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Enhanced Learning by Extending Metadata of Learning Objects with Knowledge Objects

Sai Sabitha[1], Deepti Mehrotra[2] and Abhay Bansal[3]

KEC[1], ASCS[2], Amity University, India
[1]saisabitha@gmail.com; [2]mehdeepti@gmail.com; abhaybansal@hotmail.com[3]

Abstract

Students are given a set of prescribed learning objects within a domain area in a technology supported learning environment. Learning to be effective, the content should address the needs of students with various learning styles, promote adoption of a deep approach to learning, and help students to reach a higher level of intellectual gain. The current learning environment provides an opportunity for standardization of learning objects which can be reused, recombined and adapted through the use of LOs. The quality of the learning content delivered to a user also plays an important role and determination of such quality Learning Objects (LO) involves complex processes. An added knowledge to the existing LO can surely benefit the user in many ways and can improve the quality of an object. Metadata plays a bigger role in the delivery of Learning Objects based on user queries and many metadata standards exist which helps in retrieval of these LOs. A method is proposed to tag a new extended metadata called Knowledge Object (KO) of Knowledge Management System (KMS) with LOs. The LOs and KOs can automatically be classified using data mining approaches. K-nearest neighbour approach is used to find the closest KOs to a particular LOs These KOs are considered as extended metadata to fetch a Knowledge Enabled Learning Object as a specialized Knowledge Content to users; thereby the quality of an object in a learning environment is improved.

Keywords: *Learning Objects; Knowledge Objects; Metadata; Data Mining, KNN*

1. Introduction

A LO can be of any format such as text, image, graphics, audio or video. Learning Object Repositories (LOR) helps in storing, searching, retrieving, and delivering of LOs. The LOs are fetched and delivered to the user by a data model, Learning Object Metadata (LOM). The actors involved in the life cycle of LOs are an author, publisher, repository maker, policy maker, teachers and students. Authors or teachers are the main content developers. The characteristic features of LOs are reusability, interoperability and manageability.

The learning of students can be a surface approach to learn simple facts, a deeper approach where their focus is to understand the concept and the third is a strategic approach. This detail and extent of the content provided to students may vary depending upon the students' needs. Learners have access to all of the unit content, including the assignment and other relevant resources. Students who take a deep approach to reading try to integrate summaries of material they had read, thereby interpreting the information rather than simply repeating it. In order to achieve higher-order thinking through electronic learning environments, users should correlate new information with old so that meaningful knowledge is acquired [1].

Many research works are being done and models are also proposed for improving the quality of LOs [4]. A learning content can be converged with the implicit knowledge of an

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expert (KO) from KMS to its corresponding LO. Thus the content delivered is dynamic; knowledge enriched and can help learners, especially the advance learners or deep learners. The main factors that engage a learner is by providing quality and relevant content, understanding of it and the ability to interpret it.

Our focus is to add a new metadata (KO) as an extended metadata to one or more LOs, thereby not only delivering relevant content (LOs) indented for a particular topic or lesson but these KOs added, can also help the learners with an enriched learning experience. The need and approach of aggregation of the LO and KO are also proposed many researchers [18, 12, 14].

2. Literature Survey

2.1. Learning Objects

LO according to experts is "a reusable, media-independent chunk of information used as a modular building block for e-learning content". It is "any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning" [7, 2, 17]. These objects have metadata which refers to description that facilitates & administrates these objects [16, 13].

The various metadata standards are Dublin Core Metadata [3], IEEE Learning Object Metadata [7], IMS Global Learning Consortium [8], and Advance Distributed Learning Initiative (ADLI). The IEEE metadata standard is widely used and it aims to develop accredited technical standards, and guides learning technology. It is grouped under categories like general, life cycle, meta-metadata, educational, technical, rights, relation, annotation, and classification categories. The other providers like IMS content packaging model defines a set of structures used to exchange the learning content.

2.2. Knowledge Object

Many concepts of KO have been proposed Merrill, [9] & Ruffner [11]. The tacit knowledge in a knowledge conversion process can be considered as the content of KO. According to Merrill [9] a KO is defined as a record of information that serves as a building block for any KMS. The components of KO are: information component, parts component, property component, activity component and process component. According to Horton [6],''A KO is a chunk of electronic content that can be accessed individually and it completely accomplishes a single goal''.

2.3. Metadata Creation

Metadata can be generated manually (creators and author), automatically (automated tools) or by semi automatic methods. Metadata harvesting and metadata extraction have been identified as two methods of automatic metadata generation. Metadata harvesting is the process of automatically collecting resource metadata already embedded in or associated with a resource. Metadata extraction is the process of automatically pulling metadata from the resource's content. DC-Dot is one such tool.

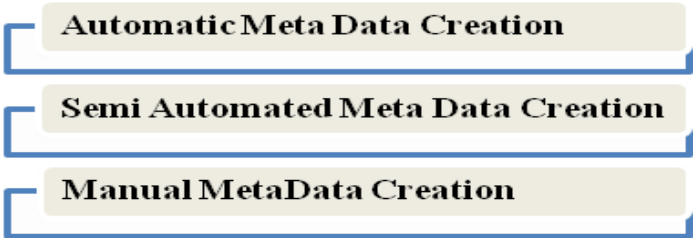

Figure 1. Types of Metadata Creation

2.4. Learning Object Repositories (LOR)

LORs help users to search for learning material and they provide simple and advanced searches. Simple search results are given based on input keywords. The advanced search allows users to specify values for specific metadata elements and filters the learning material according to the need of the user. Federated search provides the facility of searching learning materials from other repositories. The well known LORs are MERLOT, EDNA, CGIAR, CAREO, HEAL [10]. Most of these LOR follow IEEE-LOM metadata standard and metadata annotation is done manually.

2.5. Various Metadata Providers

Dublin Core metadata contains 15 metadata elements and qualifiers which are useful for general purpose applications. The IEEE Learning Object Metadata describes characteristics of the LOs and classifies into many groups like general, technical *etc*. The IMS Global Learning Consortium develops and promotes the adoption of open technical specifications for interoperable learning technology. The Can Core Learning Resource Metadata Initiative enhances the ability of educators, researchers and students around the world to search and locate materials from online collections of educational resources. Some of metadata standards and the added extended metadata are shown in "Figure 2".

IEEE LOM	CanCore	LOM Dublin Core Metadata		KO as Extended Metadata	
1. General 2. Life Cycle 3 Meta-Metadata 4. Technical 5. Educational 6. Rights 7. Relation 8 Annotation 9. Classification	1. General 2. Life Cycle 3 Meta-Metadata 4. Technical 5. Educational 6. Rights 7. Relation 8 Annotation 9. Classification	1 Contributor 2. Coverage 3. Creator 4. Date 5 Description 6. Format 7. Identifier	8. Language 9. Publisher 10. Relation 11. Rights 12. Source 13. Subject 14. Title 15. type	1. General 2. Life Cycle 3 Meta-Metadata 4. Technical 5. Educational 6. Rights 7. Relation 8 Annotation	9. Classification 10.KnowledgeObject 10.1 id 10.2 Creator 10.3 Date 10.4 Topic 10.5 Subtopic 10.6 Language 10.7 SummarisedKO

Figure 2. Metadata and KO as Extended Metadata

2.5. Data Mining

The aim of the data mining process is to extract implicit knowledge from large volumes of data sets and transform it into an understandable structure for further use. It contains several algorithms and techniques for finding novel patterns from large data sets. These are mainly classified into two categories namely, supervised learning (classification) and unsupervised learning (clustering). KNN is a non parametric lazy learner or a classifier. It does not make

any underlying assumption on the data distribution. It is a technique which uses k-instances as represented points in a Euclidean space [15, 5].

3. Need for Extended Metadata

- The primary purpose of using a metadata is its ability to describe a resource and allows the user to fetch it. Fundamentally, metadata is an enabler. Metadata attributes are abstracts, keywords, subject, file formats authors, producers, copyright and usage restrictions *etc.*. Some metadata elements often used by indexes are not included in searchers queries. In current search interfaces, searchers are not being able to find LO, because of the gap between searchers and indexers. However visualization and recommender tools may help to find a relevant LO. Classified KO added as an extended metadata does help to fetch LOs and improve the content of LO by adding a relevant KO along with it.
- Metadata is descriptive information about resources like text, image which enhances findability and the sharing of the objects. Many unstructured and unsystematic ways of classification used in information retrieval are to an extent is reducing the retrieval capability. Here the KO is structured and can be considered as an attribute in existing metadata. But it can add more essence to the learning assets to various end users. The LOM uses a hierarchical structure to organize the relationships between metadata elements and Dublin core uses a flat structure.
- Analysis, synthesis, and evaluation are skills of the highest order in *Bloom's taxonomy* and they are important in critical thinking. These Objects help in higher order thinking skills and deeper learning and multiple perspectives on the content are made available to the user.
- A learning approach, in a student depends on a particular situation which may involve complex factors. Some students possess the prerequisite knowledge, skills and motivation to learn the subject. Some students depend on an instructional environment. Here,we can add the knowledge object in the instructional environment as a factor to motivate deep approach towards learning.
- A Constructive learning approach has an instructional design that adheres to the principle of constructivism, that knowledge is constructed by the learner, as opposed to being simply transmitted by a teacher and absorbed. This extended metadata helps in such an approach.
- It enhances the current learning object metadata standards to address the learning context and pedagogical instructional role in metadata elements.
- The objects can also be reusable under various context

4. Schematic Model

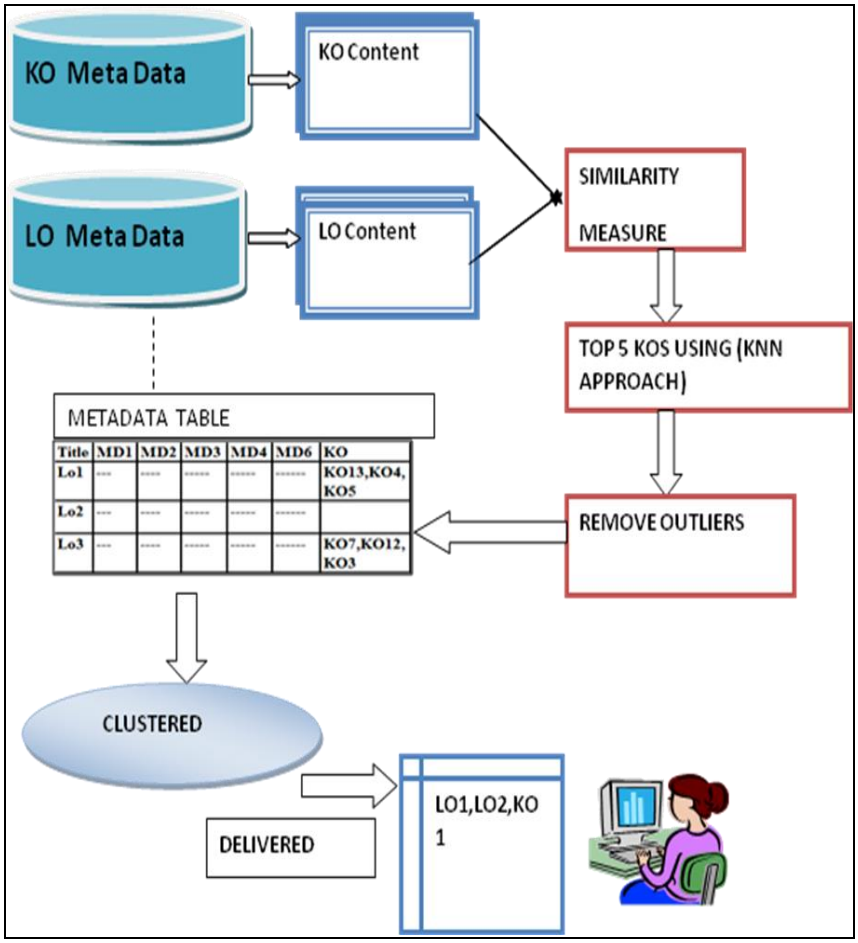

Figure 3. Schematic Model

Steps of the above Model (Figure 3).

1. Generation of LMS and LO.
2. Generation of KMS and KO.
3. Extraction of a LO from LMS and KO from KMS for a particular "topic" in a domain.
4. The proximity measures of these objects using the cosine similarity measure are calculated.
5. Based on the these measures, (Fig.5) Convergence of LO and KO through data mining "KNN classification" method is done.
6. Classified KO with LO can be called Extended Learning Object (ELO).
7. Now, for each LO we may have one or more associated ELOs which can be further considered as a part of an instructional unit.
8. These classified ELO are added in LO metadata as an extended metadata in the metadata repository.
9. Based on user query, and clustering technique a reduced and relevant LO and a set of KOs called ELO can be delivered to a user.

5. Implementation and Results

Step 1: A set of 30 LOs & 45 KOs is considered for the domain "data mining". Few records of the classified objects are shown in "Figure 4".

object	topic	subtopic	category	author name	content
KO1	DATA CLEANING	BINNING	CONCEPT	LEENU	binning methods smooth a sorted data value by consulting its neighborhood
KO10	OUTLIER	OUTLIER ANALYSIS	technique	CC	The set of objects are considerably dissimilar from the remainder of the data Example: Sports: Michael Jordon, Wayne Gretzky, ...
KO11	ASSOCIATION	FPTREE	technique	EE	FP stands for frequent pattern.
KO12	CLUSTERING	DBSCAN	concept	FF	Clustering based on density (local cluster criterion), such as density-connected points
KO13	PREDICTION	LINEAR REG	technique	CC	Numerical) prediction is similar to classification

Figure 4. Dataset for a Topic: "Data Mining"

Step 2: The similarity between content of objects in "Figure 4" is generated using cosine similarity measures and are shown in "Figure 5".

Object1	Object2	Similarity Measure
1	2	0.2877408
1	3	0.04241506
1	4	0.12719396
1	5	0.01491909
1	6	0.06201117
1	7	0
1	8	0.03396251
1	9	0.12719396
1	10	0.03076241
1	11	0.08882356

Figure 5. Similarity Measures

Step 3: K-nearest neighbour approach is used. Based on the granularity of LOs the number of closest KO can be chosen. Here the 'k' value is considered as 5. The first 5 nearest neighbours (KO) with LO and vice-versa is shown in "Figure 6"& in "Figure 7" respectively.

First 5 Knowledge Objects to Learning Objects(ids)						First 5 Knowledge Objects to Learning Objects(distance measures)					
learning objects	first_ko	second_ko	third_ko	fourth_ko	fifth_ko	learning object	first_ko	second_ko	third_ko	fourth_ko	fifth_ko
lo1	36	72	63	64	39	lo1	0.151704	0.099662	0.068197	0.067511	0.065169
lo2	36	59	40	58	71	lo2	0.148838	0.052756	0.049894	0.033763	0.033763
lo3	56	66	58	71	62	lo3	0.066084	0.05869	0.047596	0.047596	0.041129
lo4	65	41	68	36	57	lo4	0.333668	0.156482	0.091279	0.083828	0.069984
lo5	38	62	49	58	71	lo5	0.117551	0.115837	0.081938	0.074616	0.074616
lo6	62	38	49	60	40	lo6	0.373043	0.223426	0.198572	0.051569	0.048754
lo7	44	50	36	51	40	lo7	0.274847	0.203628	0.186221	0.035988	0.033911
lo8	40	64	63	39	52	lo8	0.199309	0.1788	0.080652	0.055584	0.046062
lo9	65	41	68	36	57	lo9	0.333668	0.156482	0.091279	0.083828	0.069984
lo10	53	66	58	71	52	lo10	0.147256	0.145299	0.143286	0.143286	0.134094
lo11	63	68	39	43	49	lo11	0.17761	0.12678	0.120103	0.107661	0.101836
lo12	73	75	68	72	32	lo12	0.203334	0.203334	0.137884	0.128906	0.110571
lo13	73	75	63	39	47	lo13	0.13464	0.13464	0.127011	0.083291	0.066617
lo14	43	57	68	42	58	lo14	0.090517	0.084652	0.063203	0.058012	0.054911
lo15	36	58	71	65	52	lo15	0.317685	0.039969	0.039969	0.039598	0.025949
lo16	42	58	71	52	66	lo16	0.107062	0.097425	0.097425	0.096765	0.079604
lo17	63	39	66	52	58	lo17	0.118686	0.082306	0.079443	0.078911	0.077785
lo18	68	73	75	63	44	lo18	0.196099	0.169638	0.169638	0.087672	0.087583
lo19	58	71	68	72	63	lo19	0.097707	0.097707	0.080971	0.077217	0.071931
lo20	63	39	58	71	59	lo20	0.102392	0.075099	0.074397	0.074397	0.064719
lo21	40	62	52	63	57	lo21	0.082321	0.048955	0.040477	0.039857	0.035443
lo22	46	70	58	71	63	lo22	0.119449	0.110039	0.106438	0.106438	0.095443
lo23	65	64	58	71	40	lo23	0.058951	0.058278	0.05737	0.05737	0.053585
lo24	73	75	66	63	74	lo24	0.122526	0.122526	0.085337	0.082163	0.07226
lo25	47	42	65	57	61	lo25	0.054733	0.052589	0.045838	0.0451	0.042009
lo26	47	70	46	61	63	lo26	0.104246	0.09479	0.061623	0.049112	0.045077
lo27	62	38	49	46	57	lo27	0.26555	0.179068	0.155887	0.11226	0.111182
lo28	50	58	71	55	56	lo28	0.155408	0.053016	0.053016	0.052755	0.04853
lo29	64	70	44	46	51	lo29	0.168305	0.020879	0.018497	0.017536	0.017418
lo30	41	49	32	66	35	lo30	0.186233	0.149819	0.145975	0.110842	0.110273

Figure 6. First 5 Nearest Neighbours of LOs

First 5 Learning Objects to Knowledge Objects(ids)						First 5 Learning Objects to Knowledge Object(distance measures)					
Knowledge objects	first_lo	second_lo	third_lo	fourth_lo	fifth_lo	Knowledge objects	first_lo	second_lo	third_lo	fourth_lo	fifth_lo
ko31	30	9	4	25	13	ko31	0.009182	0.004098	0.004098	0.003763	0.003477
ko32	30	12	10	9	4	ko32	0.145975	0.110571	0.041021	0.007412	0.007412
ko33	30	17	12	18	10	ko33	0.051323	0.049183	0.028216	0.024499	0.014931
ko34	30	9	4	25	13	ko34	0.010556	0.004712	0.004712	0.004327	0.003998
ko35	30	12	10	9	4	ko35	0.110273	0.085377	0.0309	0.004323	0.004323
ko36	15	7	1	2	9	ko36	0.317685	0.186221	0.151704	0.148838	0.083828
ko37	27	30	12	1	9	ko37	0.104073	0.048255	0.043456	0.042124	0.032786
ko38	6	27	5	1	24	ko38	0.223426	0.179068	0.117551	0.05014	0.040094
ko39	11	13	17	20	22	ko39	0.120103	0.083291	0.082306	0.075099	0.074127
ko40	8	21	20	22	23	ko40	0.199309	0.082321	0.063093	0.061622	0.053585
ko41	30	9	4	20	22	ko41	0.186233	0.156482	0.156482	0.048956	0.033418
ko42	16	14	25	3	9	ko42	0.107062	0.058012	0.052589	0.039437	0.032333
ko43	11	14	18	22	17	ko43	0.107661	0.090517	0.074139	0.069821	0.06745
ko44	7	12	18	4	9	ko44	0.274847	0.101355	0.087583	0.065042	0.065042
ko45	22	11	14	7	8	ko45	0.048869	0.034502	0.029349	0.028031	0.027726
ko46	22	27	11	26	24	ko46	0.119449	0.11226	0.066939	0.061623	0.050697
ko47	26	13	25	11	22	ko47	0.104246	0.066617	0.054733	0.051628	0.049954
ko48	27	30	12	1	9	ko48	0.104073	0.048255	0.043456	0.042124	0.032786
ko49	6	27	30	11	5	ko49	0.198572	0.155887	0.149819	0.101836	0.081938
ko50	7	28	18	22	9	ko50	0.203628	0.155408	0.033303	0.030799	0.028712
ko51	7	20	22	29	17	ko51	0.035988	0.019878	0.019166	0.017418	0.017361
ko52	10	16	22	17	18	ko52	0.134094	0.096765	0.095377	0.078911	0.066538
ko53	10	16	22	30	18	ko53	0.147256	0.07076	0.066144	0.059629	0.051016
ko54	30	12	7	8	10	ko54	0.050585	0.047686	0.0217	0.014337	0.014289
ko55	28	30	12	20	23	ko55	0.052755	0.051792	0.043039	0.04232	0.04224
ko56	10	3	9	4	18	ko56	0.074444	0.066084	0.060823	0.060823	0.057221
ko57	27	14	22	9	4	ko57	0.111182	0.084652	0.071988	0.069984	0.069984
ko58	10	22	19	16	17	ko58	0.143286	0.106438	0.097707	0.097425	0.077785
ko59	22	20	18	2	24	ko59	0.065124	0.064719	0.058589	0.052756	0.051006
ko60	10	22	24	16	30	ko60	0.117069	0.056832	0.05433	0.052888	0.051641
ko61	27	26	22	13	25	ko61	0.060379	0.049112	0.046111	0.045682	0.042009
ko62	6	27	5	24	1	ko62	0.373043	0.26555	0.115837	0.068356	0.056592
ko63	11	13	17	20	22	ko63	0.17761	0.127011	0.118686	0.102392	0.095443
ko64	8	29	1	22	23	ko64	0.1788	0.168305	0.067511	0.065854	0.058278
ko65	4	9	11	23	30	ko65	0.333668	0.333668	0.060653	0.058951	0.058058
ko66	10	30	24	16	17	ko66	0.145299	0.110842	0.085337	0.079604	0.079443
ko67	10	30	28	9	4	ko67	0.061825	0.047082	0.042646	0.039911	0.039911
ko68	18	12	11	9	4	ko68	0.196099	0.137884	0.12678	0.091279	0.091279
ko69	11	24	28	10	7	ko69	0.088383	0.060123	0.038394	0.028582	0.02426
ko70	22	27	26	10	11	ko70	0.110039	0.102313	0.09479	0.070742	0.061008
ko71	10	22	19	16	17	ko71	0.143286	0.106438	0.097707	0.097425	0.077785
ko72	12	1	30	19	18	ko72	0.128906	0.099662	0.089933	0.077217	0.065322
ko73	12	18	13	24	11	ko73	0.203334	0.169638	0.13464	0.122526	0.076267
ko74	12	24	30	17	19	ko74	0.089476	0.07226	0.071991	0.065859	0.055923
ko75	12	18	13	24	11	ko75	0.203334	0.169638	0.13464	0.122526	0.076267

Figure 7. First 5 Nearest Neighbours of KOs

Step 4: To find out relevant KO, a distance based outlier approach is used. The average distance between first five objects are calculated. Outliers whose average are less than 0.05 are removed. "Figure 8" shows the sorted list of outliers (KO) and their distances with respect to LO. A function in python language was coded to remove the outliers and the output of nearest KOs to LO is shown in "Figure 9".

Knowledge objects	first_lo	second_lo	third_lo	fourth_lo	fifth_lo	average
ko31	0.009182	0.004098	0.004098	0.003763	0.003477	0.004924
ko34	0.010556	0.004712	0.004712	0.004327	0.003998	0.005661
ko51	0.035988	0.019878	0.019166	0.017418	0.017361	0.021962
ko54	0.050585	0.047686	0.0217	0.014337	0.014289	0.02972
ko33	0.051323	0.049183	0.028216	0.024499	0.014931	0.03363
ko45	0.048869	0.034502	0.029349	0.028031	0.027726	0.033695
ko67	0.061825	0.047082	0.042646	0.039911	0.039911	0.046275
ko55	0.052755	0.051792	0.043039	0.04232	0.04224	0.046429
ko35	0.110273	0.085377	0.0309	0.004323	0.004323	0.047039
ko69	0.088383	0.060123	0.038394	0.028582	0.02426	0.047948
ko61	0.060379	0.049112	0.046111	0.045682	0.042009	0.048659
ko37	0.104073	0.048255	0.043456	0.042124	0.032786	0.054139
ko48	0.104073	0.048255	0.043456	0.042124	0.032786	0.054139
ko42	0.107062	0.058012	0.052589	0.039437	0.032333	0.057886
ko59	0.065124	0.064719	0.058589	0.052756	0.051006	0.058439
ko32	0.145975	0.110571	0.041021	0.007412	0.007412	0.062478
ko56	0.074444	0.066084	0.060823	0.060823	0.057221	0.063879
ko47	0.104246	0.066617	0.054733	0.051628	0.049954	0.065436
ko60	0.117069	0.056832	0.05433	0.052888	0.051641	0.066552
ko74	0.089476	0.07226	0.071991	0.065859	0.055923	0.071102
ko53	0.147256	0.07076	0.066144	0.059629	0.051016	0.078961
ko57	0.111182	0.084652	0.071988	0.069984	0.0699984	0.081558
ko43	0.107661	0.090517	0.074139	0.069821	0.06745	0.081917
ko46	0.119449	0.11226	0.066939	0.061623	0.050697	0.082194
ko39	0.120103	0.083291	0.082306	0.075099	0.074127	0.086985
ko70	0.110039	0.102313	0.09479	0.070742	0.061008	0.087778
ko50	0.203628	0.155408	0.033303	0.030799	0.028712	0.09037
ko40	0.199309	0.082321	0.063093	0.061622	0.053585	0.091986
ko72	0.128906	0.099662	0.089933	0.077217	0.065322	0.092208
ko52	0.134094	0.096765	0.095377	0.078911	0.066538	0.094337
ko66	0.145299	0.110842	0.085337	0.079604	0.079443	0.100105
ko58	0.143286	0.106438	0.097707	0.097425	0.077785	0.104528
ko71	0.143286	0.106438	0.097707	0.097425	0.077785	0.104528
ko64	0.1788	0.168305	0.067511	0.065854	0.058278	0.10775
ko41	0.186233	0.156482	0.156482	0.048956	0.033418	0.116314
ko44	0.274847	0.101355	0.087583	0.065042	0.065042	0.118774
ko38	0.223426	0.179068	0.117551	0.05014	0.040094	0.122056
ko63	0.17761	0.127011	0.118686	0.102392	0.095443	0.124228
ko68	0.196099	0.137884	0.12678	0.091279	0.091279	0.128664
ko49	0.198572	0.155887	0.149819	0.101836	0.081938	0.137611
ko73	0.203334	0.169638	0.13464	0.122526	0.076267	0.141281
ko75	0.203334	0.169638	0.13464	0.122526	0.076267	0.141281
ko65	0.333668	0.333668	0.060653	0.058951	0.058058	0.169
ko62	0.373043	0.26555	0.115837	0.068356	0.056592	0.175876
ko36	0.317685	0.186221	0.151704	0.148838	0.083828	0.177655

Figure 8. Distance Based Outliers

```
def fun1(a,b):
  w=a.split()
  w1=b.split()
  c=[]
  for i in range(0,45):
    w[i]=float(w[i])
  c1=[]
  for i in range(0,45):
    w1[i]=int(w1[i])
  for i in range(0,45):
      for j in range(i+1,45):
          if(w[i] < w[j]): # similarity > is
converted to <
                t=w[i]
                w[i]=w[j]
                w[j]=t
                t1=w1[i]
                w1[i]=w1[j]
                w1[j]=t1
  return w,w1
```

```
outlier=[31,  34,  51,  54,  33,
   45,  67,  55,  35,  69,  61,
   37,  48,  42,  59]

k=1
i=0
while(i!=30):
  aa1,aa=fun1(obj[i],ans)
  print k,'\t',
  for j in range(0,6):
    if aa[j] not in outlier : print aa[j],'\t',# to
remove outliers
      #print aa1[j],'\t',
  k=k+1
  i=i+1
  print
print
```

outliers are removed

learning objects	first_ko	second_ko	third_ko	fourth_ko	fifth_ko
lo1	36	72	63	64	39
lo2	36	40	58	71	56
lo3	56	66	58	71	62
lo4	65	41	68	36	57
lo5	38	62	49	58	71
lo6	62	38	49	60	40
lo7	44	50	36	40	70
lo8	40	64	63	39	52
lo9	65	41	68	36	57
lo10	53	66	58	71	52
lo11	63	68	39	43	49
lo12	73	75	68	72	32
lo13	73	75	63	39	47
lo14	43	57	68	58	71
lo15	36	58	71	65	52
lo16	58	71	52	66	53
lo17	63	39	66	52	58
lo18	68	73	75	63	44
lo19	58	71	68	72	63
lo20	63	39	58	71	52
lo21	40	62	52	63	57
lo22	46	70	58	71	63
lo23	65	64	58	71	40
lo24	73	75	66	63	74
lo25	47	65	57	58	
lo26	47	70	46	63	62
lo27	62	38	49	46	57
lo28	50	58	71	56	52
lo29	64	70	44	46	57
lo30	41	49	32	66	72

Figure 9. Function (Python) and Relevant KOs

Step 5: According to the "Figure 9", LO1 nearest neighbours (Knowledge Objects) are: - ID36, ID72, These ids can be considered and stored as extended metadata and it can be added as follows:

id	Metadata1	Meta data2	Meta data_n	KO as Extended Metadata
Lo1	—	—	—	Ko36,ko72
Lo2	—	—	—	Ko36,ko40
Lo3	—	—	—	—
	—	—		

Figure 10. Extended KOs

Step 6: The content of these ELOs can be delivered along with a clustered group of LOs or they can be summarised and delivered to the user. A clustering tool for k-mean clustering was used. The value of 'k' was taken as 6. The clustered formed are shown below:

SNO	topic	subtopic	LO_ID	KO_ID	KO_ID	KO_ID	KO_ID	KO_ID	CLUSTER_ID
3	INTRODUCTION	DATA WAREHOUSE	lo3	56	66	58	71	62	c_kmeans_1
10	DATA MINING TECHNIQUES	ASSOIATION	lo10	53	66	58	71	52	c_kmeans_1
12	DATA MINING TECHNIQUES	CLASSIFICATION	lo12	73	75	68	72	32	c_kmeans_1
16	OBJECTIVE MEASURE	SUPPORT	lo16	58	71	52	66	53	c_kmeans_1
18	OBJECTIVE MEASURE	LIFT	lo18	68	73	75	63	44	c_kmeans_1
19	OBJECTIVE MEASURE	RECALL	lo19	58	71	68	72	63	c_kmeans_1
22	DATA MINING APPLICATIO	TEMPORAL MINING	lo22	46	70	58	71	63	c_kmeans_1
23	DATA MINING APPLICATIO	SPATIAL MINING	lo23	65	64	58	71	40	c_kmeans_1
24	DATA MINING APPLICATIO	TIME SERIES MINING	lo24	73	75	66	63	74	c_kmeans_1
26	PRE PROCESSING	DATA CLEANING	lo26	47	70	46	63	62	c_kmeans_1
4	KNOWLEDGE DISCOVERY	PATTERN EVALUATION	lo4	65	41	68	36	57	c_kmeans_2
9	PATTERN EVALUATION	INTERESTING MEASURES	lo9	65	41	68	36	57	c_kmeans_2
13	DATA MINING TECHNIQUES	PREDICTION	lo13	73	75	63	39	47	c_kmeans_2
17	OBJECTIVE MEASURE	CONFIDENCE	lo17	63	39	66	52	58	c_kmeans_2
7	PRE PROCESSING	DATA SELECTION	lo7	44	50	36	40	70	c_kmeans_3
11	DATA MINING TECHNIQUES	CLUSTERING	lo11	63	68	39	43	49	c_kmeans_3
27	PRE PROCESSING	DATA INTEGRATION	lo27	62	38	49	46	57	c_kmeans_3
29	PRE PROCESSING	DATA TRANSFORMATION	lo29	64	70	44	46	57	c_kmeans_3
30	PATTERN EVALUATION	INTERESTING MEASURES	lo30	41	49	32	66	72	c_kmeans_3
2	INTRODUCTION	KNOWLEDGE DISCOVERY	lo2	36	40	58	71	56	c_kmeans_4
5	PRE PROCESSING	DATA CLEANING	lo5	38	62	49	58	71	c_kmeans_4
8	PRE PROCESSING	DATA TRANSFORMATION	lo8	40	64	63	39	52	c_kmeans_4
14	DATA MINING TECHNIQUES	OUTLIER ANALYSIS	lo14	43	57	68	58	71	c_kmeans_4
15	ISSUES	TASK PRIMITIVE	lo15	36	58	71	65	52	c_kmeans_4
21	DATA MINING APPLICATIO	WEB MINING	lo21	40	62	52	63	57	c_kmeans_4
28	PRE PROCESSING	DATA REDUCTION	lo28	50	58	71	56	52	c_kmeans_4
1	INTRODUCTION	DATA MINING	lo1	36	72	63	64	39	c_kmeans_5
25	DATA MINING APPLICATIO	multimedia mining	lo25	47	65	57	58	0	c_kmeans_5
6	PRE PROCESSING	DATA INTEGRATION	lo6	62	38	49	60	40	c_kmeans_6
20	DATA MINING APPLICATIO	TEXT MINING	lo20	63	39	58	71	52	c_kmeans_6

Figure 11. Clusters

Step 7: Learning Object_27 of cluster_3 belongs to the topic "data integration", the knowledge objects ko62, ko38, ko49 also belong to the same topic "data integration" as shown below. Thus for a given topic a set of LOs and relevant KOs can be delivered.

PRE PROCESSING	DATA INTEGRATION	lo27
DATA INTEGRATION	SCHEMA INTEGRATION	ko62
DATA INTEGRATION	SCHEMA INTEGRATION	ko38
DATA INTEGRATION	SCHEMA INTEGRATION	ko49

6. Conclusion

Instructional Theory is defined as identifying methods that will best provide the conditions under which learning goals will most likely be attained. The best instructional technique is determined by the objective(s) to be learned. One such objective for enhanced learning can be achieved by adding a KO as an extended metadata. Static learning content is enhanced by providing an expert knowledge (KO) as an added content to the learners. This content delivered is dynamic; knowledge enriched and can help learners specially the users of higher order thinking skills. This can help the student to get that extra edge of learning and prepare them for various forms of assessment. Embedding the KO with a LO gives a context-driven architecture in which the learner is provided with facts and information, thus multiple perspectives on the content are made available. Hence quality resources can be delivered to the student. These classified ELOs can be clustered or summarized and delivered.

7. Abbreviations

LO : Learning Object
KO : Knowledge Object
LMS : Learning Management System
KMS : Knowledge Management System
LOR : Learning Object Repository
KNN : K-Nearest Neighbour
MERLOT : Multimedia Educational Resources for Learning and Online Teaching
EDNA : The Education Network Australia
CAREO : Campus Alberta repository of educational objects
HEAL : Health education assets library.
LTSC : Learning Technology Standards Committee

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Authors

Mrs **Sai Sabitha,** is BE (CS), ME (CS) in Computer Science and engineering. She is Associate Professor (CSE), KEC Ghaziabad. She is pursuing Ph.D. Programming in Computer Science & Engineering. She has published research papers in conferences & journals. She has over 14 years of Academic and industry experiences. She has handled various B. Tech & M. Tech Projects. Her area of interests are e-Learning, Knowledge Management, Data Mining, Artificial Intelligence & Web Technologies.

Dr. Deepti Mehrotra is a gold medalist of Lucknow University and had received Ph.D. from Lucknow University. Currently, she is Director of Amity School of Computer Science, Noida, India. She has more than 18 years of experience in teaching, research and content writing. She had published more than 50 papers in international refereed Journals and conference Proceedings. She is a member of many committees like member of Board of Study of various Universities, member of the DRC of Amity University and reviewer for many referred journals and conferences. She is regularly invited as resource person for FDPs and invited talk in national and international conference. She is currently guiding 7 Ph.D. and four M.Tech. scholars.

Dr. Abhay Bansal is BE (CS), ME (IT), MBA and PhD. He is Professor & HOD (CSE), ASET & Director, DICET, Amity University, Noida. With over 19 years of Industry and Academic Experience, Dr. Bansal has regularly contributed more than 40 papers in various International journals/conferences. He is a fellow of the Institution of Engineering and Technology (U.K), Sr. Member, International Association of Computer Science and Information Technology. He is a member of ISTE, IEEE (USA), ACM, IETE. He is also a Microsoft Certified Professional and Microsoft approved Technical Associate. He has been an active member and Chairman of the programme committees of several National and International conference/seminar. He is also a reviewer of various National/ International Journals of repute.