Ontological structure representation in reusing ODL learning resources

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Abstract
Purpose – The purpose of this paper is to reuse learning resources from course module and forum discussion in ODL settings and structure it with ontological representation.
Design/methodology/approach – Thus, an ontology is designed by extending simple knowledge organization system specification to structure the learning resources. Furthermore, a semantic forum system is proposed as a front end mechanism to represent the ontological structure designed for the learner to easily access, search and navigate the relevant knowledge of interest. In addition, this study evaluates the effectiveness of the proposed system along with three variables, namely, learners' perceptions, system design perceptions and system content perceptions. Accordingly, a close-ended online survey was developed and administered to 74 online learners.
Findings – The findings demonstrate positive perceptions of the proposed system which is based on ontological representation as an effective learning system that is able to enhance the understanding of courses taught.
Originality/value – This paper presents an ontological structure approach to add meaning to the learning resources, indexed in such a way that it can be reused, searched, processed and shared.
Keywords Ontology, Course module, Forum discussion, ODL education, Semantic forum, SKOS
Paper type Research paper

Introduction
The success of ODL education highly depends on how well the course offer is designed, evaluated and delivered. Many have suggested ODL institution to focus on exploring and developing new learning technologies to further facilitate learning and improve the effectiveness of the education (Koper, 2013). Despite various web-based learning resources that are managed through the use of learning management system, the main learning resource still highly depends on course module or textbook and forum discussion. A course module refers to a unit of teaching or an academic learning material taught in a semester or one academic term (Hashim and Noah, 2015). Basically the course module content is structured according to topics, subtopics for the course of concern. Forum discussion provides a platform or space to communicate, share opinions, solve problems, articulate and collaborate in their learning process. This platform is capable of archiving posted questions, answers or discussions from various courses over the semesters.
Knowing the importance of the learning resource, reusing such content is highly valuable to enhance learning of the course taught however, only few have taken the effort to reuse these resources. The reason mainly cause from the difficulty of forum discussion platform to classify and extract the relevant questions and answers pertaining to subject matter, so do to the effort to integrate it with course module content. Therefore, this study aims to reuse learning resources from course module and forum discussion and structure it with ontological representation.

Ontological structure representation
The term ontology is borrowed from philosophy field which is concerned with being or existence study. In the context of computer and information science field, ontology denotes as an artefact that is designed to model any domain knowledge of interest. The most widely cited definition of ontology in the computer field is from Gruber (1995) defines it as an “explicit specification of a conceptualization”. In other words, it means that ontology is able to explicitly define (specifies) concepts and relationships that are relevant for modelling domain of interest. The specification can takes in the form of classes, relations, constraints and rules to provide more meanings of vocabulary use. The use of ontology structure has already been recognized in ODL education for framework development (Sarwar et al., 2016), learning analytics (Okoye et al., 2016), learning experiences and learning materials (Chung and Kim, 2016).

In order to describe the importance of ontology in structuring the knowledge of interest, Figure 1 shows a level of semantic, where ontological structure represents the highest semantic richness or strong semantics of all knowledge organization systems. Meanwhile, Figure 2 illustrates on how ontology can be used as a mechanism to add
semantics into web resources. For example, an illustration of normal web is shown on
the left side of the figure. It indicates that resources are linked together and there is no
distinction between resources or the links. Meanwhile an illustration of semantic web is
shown on the right side of the figure. It indicates all the resources and links were given
meaning individually and precisely. This implementation is feasible by the used of
ontological structure aided with semantic web technologies standard and languages.

This study made an effort to reuse learning resources from system analysis and
design (SAD) course module and its forum discussion. The SAD course is chosen as it is
a compulsory subject that being offered every semester. In the aspect of developing the
ontological structure, the development is based from Uschold and Gruninger (1996)
ontology engineering method. The engineering method initiated with the identification
of the key concepts and relationships in the interest domain. Second, with the
identification of precise unambiguous text definitions for such concepts and relationships.
Third, with the identification of terms to refer to such concepts and relationships, and
finally, reaching agreement on all of these.

In order to offer semantic richness from the designed ontology, the initiative to
reuse specification from existing standard ontology is a priority. Thus, this study
extends simple knowledge organization systems (SKOS) ontology developed by the
World Wide Web Consortium (W3C) community as a standard to classify and index the
learning resources. SKOS is a standard ontology to model knowledge organization
systems via web, namely, thesauri, taxonomies, classification schemes, structured
controlled vocabulary and subject heading systems (Miranda et al., 2016). Thus, the
SKOS specification for the ontology designed is referred as in Figure 3.

The process to capture the learning resources into ontology began with structuring the
SAD course into concepts and its relationships according to SKOS specification. In brief,
concept can be referred as keywords or key terms which are highlighted in the course
module. For further explanation, Figure 4 provides an example of identified concept and

![Figure 3. SKOS specification](image-url)

Source: Baker et al. (2013)
its relationships according to SKOS specification from the course module. The effort to organize the concepts according to its appropriate relationship types assist learners to visualize of what is important and should be learned from the course more precisely.

The TopBraid Composer is an authoring tool as illustrated in Figure 5 was used to encode the course module content in ontology using Web Ontology Language (OWL). OWL is a language developed by W3C which is part of semantic web languages. This language explicitly defines SKOS specification with concepts and relationships in its vocabulary. OWL represents those concepts in the form of triples representation (subject, property, object) as depicted in Figure 6.

Semantic forum system
The process to capture relevant content from course module and its forum discussion into ontological structure was carried out by knowledge engineer. This tasks required
knowledge engineer to have appropriate ontological engineering method, languages and authoring tool background. In addition, a front end mechanism is needed to interact with the designed ontology. Thus, this study proposes a semantic forum system for learners to easily access, search and navigate the relevant knowledge of interest. The system introduces a new way of storing, organization, searching and exchange relevant concepts and discussions that able to facilitate the course to be reused, evolved and resolved learning difficulties. Thus, this section briefly discusses the proposed system’s facilities and its usage.

Figure 7 illustrates an interface that provides concept information details. The information includes: concept section: to display the concept name, and its relationships such as narrower concept, broader concept or related concept; notes section: to display important information that need to be learned of such concept; others section: to display synonyms of such concept in English or native language as well as links to other relevant sources; and related questions section: to display relevant questions and
answers extracted from the forum over the semesters. Moreover when learners post new questions, the related questions section will be evolved with new choices of question for further understanding and revision.

Figure 8 illustrates list of discussion questions organized under certain concept category. The function of this category is to deliver the main group of concepts from the course structure. Upon category selection, all questions tagged under that category will appear with information such as question types, author, date and time and the tagged concept. Obviously with this learning facility learners have option to choose whichever questions in the system collection even though they just started learning the subject. Furthermore, choices of answers will also be displayed upon question selection as depicted in Figure 9. The system provides a facility for learners to add in new
answer or to recommend the existing answers. Once recommended the system will count for popularity of the recommended answer that best reflect their understanding.

Meanwhile, Figure 10 illustrates concepts and relationships between the concepts using concept maps diagram. This initiative contributes to reflect the big picture and the essential aspects of what is important and needs to be learned from the course taught. One of main features of the system is the searching facilities. The system provides few searching types, namely, concept search, similar questions, unanswered questions, new questions, new answers, question types and recommended answers. For example depicted in Figure 11, it shows the facility of searching by question types. This search classifies questions by comparison, definition, example, clarification and verification type of question.

**Evaluation results and discussion**

The aim of this paper is to reuse course module and forum discussion with ontological representation structure. Nevertheless, formal evaluation method is needed to maximize the benefits and potential in using the designed ontology with the proposed system as the front end mechanism. Thus, the independent variables, namely, learners’ perceptions, system design perceptions and system content perceptions were measured against the dependent variable namely perceived effectiveness of the system. The development of evaluation items were referred from previous studies mainly from Liaw (2008), Sun et al. (2008), Shee and Wang (2008), Wang et al. (2007), Li et al. (2009), Ozkan and Koseler (2009), as described in Table I.

This study measures the three independent variables with following hypotheses:

\[ H1. \text{ Learners’ perceptions are positively related to the perceived effectiveness of the system in enhancing learners’ understanding of the course.} \]
H2. System design perceptions are positively related to the perceived effectiveness of the system in enhancing learners’ understanding of the course.

H3. System content perceptions are positively related to the perceived effectiveness of the system in enhancing learners’ understanding of the course.

The selection of the participants was limited only for SAD course learners’ enrolment. In other words, only those who enrolled for the course, were asked to participate in evaluating the system which offer SAD content. Participants received a brief tutorial on the system prior to beginning of the study. The response rate is 80 percent, from target population size of 92 online learners. Only 74 online learners responded after their interactions with the system by filling up the close-ended online survey. The online survey was administered for one month with incomplete responses and missing values deleted. Participation is voluntary basis.

Evaluation results
To examine the data, statistical methods have been used. Descriptive statistics were run to analyse the collected data using Statistical Package for the Social Sciences version 21.

In summary the descriptive data collected from survey results for each independent variables namely learners’ perception are high (mean value 4.25), system design perception is high (mean value 4.24) and system content perception is high (mean value 4.06). The mean value for the dependent variable perceived effectiveness of the system is high (mean value 4.36). In addition to descriptive statistics, result from multiple regression analysis was analysed in order to measure postulated hypotheses depicted in Table II. In brief, this analysis meant to measure whether the independent variables namely learners’ perception, system design perception, and system content perception are significant predictors of the dependent variable (perceived effectiveness of the system).

One of the main elements in regression analysis is to test the relationship between the dependent variable with each predictor known as standardized coefficients $\beta$. Thus, the result indicates each of the predictor shows positive $\beta$ values. In other words, it means that the participant who perceived positively or perceived positively on system content or perceived positively on system design will likely to perceive positively on the

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learners’ perceptions</td>
<td>System value – whether the system is a valued tool for learning</td>
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<tr>
<td></td>
<td>System usefulness – whether the system is useful for learning</td>
</tr>
<tr>
<td></td>
<td>Ease of use – whether the system is easy to use for learning</td>
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<tr>
<td></td>
<td>Ease of understanding – whether the system eases the learning process</td>
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<tr>
<td>System design</td>
<td>System search – whether the provided search feature can fulfil learning needs</td>
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<tr>
<td>perceptions</td>
<td>System organization – whether the system organized with the concept organization can enhance learning</td>
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<td></td>
<td>System navigation – whether the system is easy to navigate for finding the required information</td>
</tr>
<tr>
<td>System content</td>
<td>Content availability – whether the content is available to be used with a variety to be chosen from</td>
</tr>
<tr>
<td>perceptions</td>
<td>Quality content – whether the content is easy to understand, clear, and relevant</td>
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<tr>
<td></td>
<td>Useful content – whether the content indicates what is important and needs to be learned</td>
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Table I. Details of evaluation variables and items
system effectiveness as well. In particular, the $\beta$ value for each predictor namely learners’ perception is 0.274, system design perception is 0.374 and system content perception is 0.302. The regression analysis indicates that all the predictors made a statistically significant contribution with $p$ value $< 0.05$. Each of the predictor $t$ value namely learners’ perception is 2.75, system design perception is 3.33 and system content perception is 3.16. This means that the system design perception with a higher $t$-value indicates a bigger contribution to the system effectiveness perception compared to the other two predictors. In other word, it can be stated that learners who perceived positively towards system design claim it as the most effective predictor that able to enhance their understanding of the course taught.

Discussion
System design perception variable measures searching, organization and navigation facilities of the semantic forum system. Results from a multiple regression analysis indicated that system design perception is the most important and highly significant predictor of the perceived effectiveness of the system, compared to the other two predictors. The results from the descriptive data also indicated a high mean value for each of the instrument factors. Thus, it can be concluded that facilities provided were positively accepted and effective to be used in enhancing learners’ understanding of the course. This positive perception is justifiable with the new facilities designed offer an advantage to successfully ease the searching to filter out irrelevancy and ease the navigation especially when learning resource grows larger. The organization driven by concept relationships representation that concern to illustrates essential aspect of course taught crucial in enhancing the understanding process. This effort is consistent with previous research that emphasized on the importance to develop functions or facilities that able to increase learning effectiveness and meaningful learning experience (Laurillard et al., 2013; Miranda et al., 2016).

System content perception variable measures the factors of content availability, quality and usefulness, was identified as the second most important predictor of the perceived effectiveness of the system. This was indicated with positive and significant results from multiple regression analysis. The positive perception is justifiable as learners were provided with course module and forum discussion content from current and previous semesters offer valuable advantage for immediate feedback and
additional learning resources that will enhance their understanding. The initiative to reuse variety of posted discussion in the system able to assist learners in their revision and understanding of the course. Furthermore, the system provides the facility to filter related subject matter content which tags to appropriate concepts. For this reason, learners are able to increase their concentration with the learning material that matches with the course learning objectives.

Learners’ perceptions variable measures learners’ perceptions of the system’s value, its ease of use, the ease of understanding it and its usefulness. This variable was identified as the third important predictor of the perceived effectiveness of the system, indicated by the regression analysis result. This positive perception is important, as learners who place a high value on system designed are likely to spent more effort in learning, applying more elaborated learning strategies and devoting more time to learn. Prior studies have considered positive learners’ perceptions as contributing to the effectiveness of ODL application as well as to intentions to use the system (Lee, 2013; Huang et al., 2010).

Conclusion
As learning resources continue to rapidly grow, so do expectations on ways to reuse these resources are becoming more important and critical to accommodate desirable learning outcome. Thus, this study contributes to introduce ontological structure representation in reusing the learning resources from course module and forum discussion. This representation is central to add meaning to the learning resource, indexed in such a way that it can be reused, searched, processed and shared the knowledge of interest. However, to make it accessible for the ontological structure designed, a semantic forum system is proposed as a front end mechanism in bringing the learning experience to the next level.

The proposed system is designed with concepts and relationships organization can be a valuable means to highlight the essential aspect of the course of what is important and need to be learned. The initiative to reuse these learning resources is significant to enrich further learning and revision with relevant learning resources. Furthermore, positive perceptions findings from the evaluation add in the value that the system with ontological structure is an effective learning system to enhance learners’ understanding of the course taught. This study provides insights on the new technology driven by ontological structure representation that can be used to further strengthen ODL learning needs and outcome. Future research efforts to be considered are to deliver the system that can matches various teaching strategies namely game base learning, simulation, role playing and case study or preferred learning style by varying the sequentialization of learning resources.

References


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