Domain-Oriented Approach to the Reuse of Learning Knowledge: An Overview

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Abstract

This paper surveys domain-related literature in software engineering and learning technology areas, and proposes a new domain axis of learning strategy. Domain model development is useful to reuse domain knowledge, and improve productivity and quality of courseware development. In general, a domain is defined as a certain level of learning resource hierarchy: a unit, a course, or a subject. To construct a domain-dependent model of learning strategy for objective learning activity, feedback and navigation framework will be structured and reused. An example of navigational domain model is stated in science area.

1. Introduction

Domain analysis / modeling researches originated from software engineering area [2, 9, 16]. The main objective of these researches is the reuse of systemrelated information identified in requirement analysis, design, and implementation phases. Software designers often develop many similar systems in the same business field. In these cases, reuse of requirement or design specification often results better quality and productivity for the target system developments. Extracting activity of inter-system specification is called domain analysis, and resulting information is called domain model.

Domain analysis forms a group of similar business specification as one "domain" in order to extract common vocabulary, structure, attributes, and relationships. When developing a new system, a designer is able to start to clarify the commonality and difference between the domain model and the target system, and then he reuses and modifies the domain model to fit the target system. For example, Fischer [4, 5] introduces domain-specific knowledge processing method into software design environment. He proposes some systems to support and accelerate the use of domain knowledge for distributed and collaborative design activity. Cybulski [3] proposes to measure the similarity of different business specification quantitatively, in requirement analysis phase. Henninger [7, 8] archives and reuses specific business knowledge and development experience as domain model.

Also in the area of Artificial Intelligence and Machine Learning, knowledge acquisition and representation research focuses on a domain model. Leake [12] introduces "transformational analogy process" to assess similarity between the knowledge for case based reasoning. Oehlmann [15] adopts domain-specific metacognitive approach into case based reasoning. Kautz [10] introduces domain-specific procedures in integer planning system SATPLAN to accelerate the problem solution speed.

In the area of Ontology research, importance of domain-oriented approach is also suggested. Ontology provides a framework to represent the knowledge in general, and also distinguishes the knowledge of domain independent from one of domain dependent. For example, Kent [11] proposes Conceptual Knowledge Markup Language (CKML), which transforms generic ontology representation into domain-specific data type definition. Pérez [15] distinguishes domain knowledge representation (ontology) from problem solution description as generic inference knowledge. Seta [17] discusses "Task Ontology" as generic and problem solving framework independent from domain-specific knowledge.

In the learning technology area, there are some researches to mention domain-oriented approach. Alexander [1] reviews over 90 papers to study the interaction of domain-specific and strategic knowledge. He mentioned the effectiveness of "multi-strategy" approach for learning. Süß [19] developed XML-based language that supports multi-strategy approach of Behaviorism, Cognitivism, and Constructivism. Sparks [18] points out that there are many reusable commonalities between different courseware in the same domain.

In standardization activity in learning technology area, some description formats of knowledge model are proposed. SCORM (Sharable Courseware Object Reference Model, http://www.adlnet.org/) intends the standardized description of knowledge model for learning activities. CAM (Content Aggregation Model) draft in SCORM has functions of "catalog" to describe taxonomy and "relation-kind" to describe relationships.

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There are many indications that learning knowledge has both "domain-independent" feature and "domainindependent" one. But there are few to focus on the effect of domain model reuse. For strategic knowledge, ontology researches [15, 17] highlight the problemsolving methods. Alexander [1] also points out the importance of strategic knowledge.

2. Framework of Domain Model

Instructional design has a premise that learning resources are organized as a hierarchy shown in Figure 1. Learning resources are divided into many subjects according to the institution. One subject is divided into many units; one unit is divided into many atomic materials and examinations. Once this hierarchy is defined, sequence is automatically determined to show materials and tests.

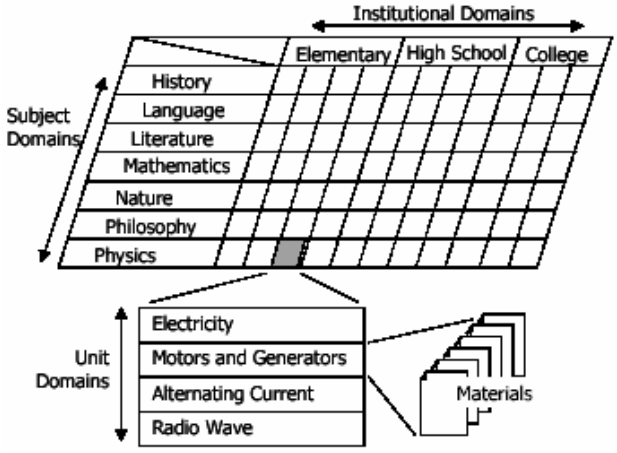

Figure 1. Hierarchical Domain Model.

However, learning activity will not complete only with the understanding these materials. Skill of absorbing, recalling, joining, applying and selecting learnt information is another important issues in learning activity. These skills are called learning strategy. Learning strategy is domain dependent, but some strategy is reusable to other domains.

Moreover, navigational skill of teachers or mentors is the part of information of learning activities. Learners of misunderstanding state or insufficient knowledge are desirable to receive appropriate feedback or navigation for objective learning achievement. This is called "instructional strategy". This strategy is thought to be relevant to the learning strategy, and also be domain dependent. This instructional strategy can be implemented as some specific framework of navigation. SCORM 1.2 specification has a straightforward and simple navigation flow, but it will be more flexible to reflect the navigation framework based on learning and instructional strategy.

When these strategies are identified as a part of a domain model, learning material development will have a new way to accelerate its productivity and quality. Even if one develops learning materials of different subjects, he is able to reuse navigation and feedback framework if these two subjects share the common learning or instructional strategy.

3. Example

Suppose two subjects on senior high school, Mathematics and Physics. From material point of view, these two subjects treat rather different materials. So reuse of material itself is limited. For example, trigonometric function is introduced in the unit "variations of functions" in Mathematics II, and also is applied in the unit "alternating current" in Physics II. Reuse is limited to common basic knowledge of functions.

However, these two subjects have some commonality from strategic point of view. Figure 2 shows a problemsolving framework in Japan ministry's curriculum guideline in mathematics. It represents the key learning strategy.

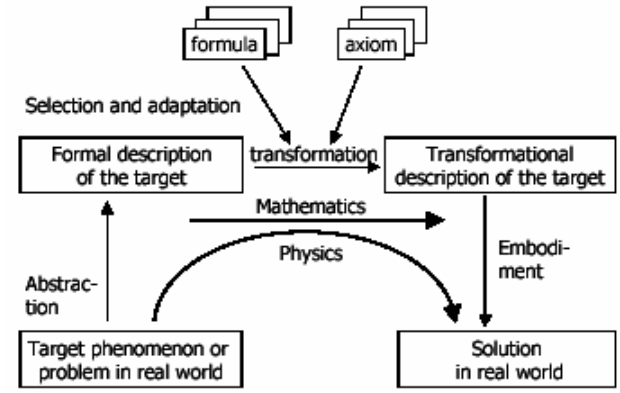

Figure 2. Problem-Solving Framework.

This framework is partially applicable to physics. In mathematics, most problem solution starts with formal description of the target, and the resulting formula or number will be the answer directly. In physics, usual exercises and problems start with abstraction process: problem or phenomena in the real world would be represented to some formulas. Then the succeeding process of transforming formulas is rather common with one of mathematics.

This example shows that reusability of learning resources extends to a different learning domain, for example from mathematics to physics. At the same time, these two learning units require different learning strategies. So it becomes clear that reusability of learning resource and learning strategy is independent.

4. Conclusion

A new axis of learning activity for learning domain model is proposed. Reusable domain model is creatable not only from material point of view, but also strategic point of view. Once a domain model developed, it is useful to reuse domain knowledge, and improve productivity and quality of courseware development. Further construction and reusability verification activity is needed for the future.

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