IDont : An Ontology Based Educational Modeling Framework for Instructional Design

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IDont: An Ontology Based Educational Modeling Framework for Instructional Design

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Abstract—It is inevitable to make use of technology to support 287 million adult illiterates spread across 22 Indian Languages and dialects. How to reduce the complexity during the creation and maintenance of adult literacy instructional design (goals, process, context, content and so on) while addressing large scale and variety? In this paper, we motivate the need for ontologies to address this inherent complexity in adult literacy problem. To this end, we present an ontology based educational modeling framework called IDont to capture different aspects of adult literacy instructional design. The core idea of this ontological framework is to systematize, separate and capture different aspects of adult literacy instructional design through several modular interrelated ontologies for context, goals, process, instructional material, role, evaluation and environment. Even though IDont is broadly applicable to all forms of educations in principle, we confine and present its application to adult literacy case study in this paper.

Keywords-ontology; framework; modeling; separation of concerns; process; instructional material; adult literacy

I. BACKGROUND - ADULT LITERACY IN INDIA

The National Literacy Mission (NLM) of Government of India has produced a uniform learning methodology called Improved Pace and Content of Learning (IPCL) to address the mammoth 287 million adult illiterates spread across 22 Indian Languages [1]. The core idea of IPCL is to take adult learners from known to the unknown and teach them 3Rs (Reading, writing and arithmetic) using thematic content [1]. Despite tremendous technological efforts to address adult literacy in India [2] and our work in the last six years [3], we have observed that adult literacy instructional design and technology are complex and current technologies do not systematically model different aspects (goals, process, content and so on) of adult literacy instructional design.

Most importantly, a large amount of knowledge related to adult literacy instructional design is not explicitly modeled.

II. INTRODUCTION & RELATED WORK

How to address the above challenges and future needs of adult literacy and systematically model adult literacy instructional design knowledge?

Despite significant attention for educational modeling languages (EMLs) [4] and IMS LD [5], there is also strong reluctance because of their inherent complexity [6]. A separation of concerns approach is an interesting way to reduce complexity while modeling educational content [7]. On the other hand, ontologies are increasingly becoming prominent to model educational content [8], learning design using IMS LD [5] and other aspects of instructional design (ID) like context as in LOCO [9]. Extending these ontologies further, an ontology framework was designed for creating an intelligent learning organization [10]. The main focus of this paper is to explore and leverage the use of ontologies to model different aspects of ID and address the challenges in adult literacy instructional design. Additionally, ontologies also have a strong potential to address future needs of adult literacy like adaptation and personalization, enabling collaboration, coordination and communication among various stakeholders, automatic content generation, collaborative and global development of educational content and so on.

However, in this paper we reduce our scope to systematically capture different aspects of adult literacy instructional design using ontologies and present a modeling framework.

III. IDONT - AN ONTOLOGY BASED EDUCATIONAL MODELING FRAMEWORK

Instructional design is a complex discipline involving multiple perspectives with several connotations even for the notion of educational content. We rely and base the design of IDont on existing ontologies like ALOCoM [8], IMS LD [5], LOCO [9], IntelLEO [10] and adapt and extend them for the requirements of adult literacy instructional design. Our major design decisions and guidelines for IDont are:

- Simplicity & separation of concerns approach
- Leverage and reuse existing ontologies
- Align with instructional design
- Be extensible and customizable
- Follow an iterative and collaborative approach
- Allow for internationalization of ontologies
- Design technology and tools supporting the framework

While it is impossible to model every aspect related to ID because of the complexity and the large number of concepts in the domain, the core idea of IDont is to reduce this complexity by defining a set of interrelated modular ontologies that support better modeling of ID. As such, most of the aspects of IDont are optional and can be configured based on specific purposes and learning scenarios.

Figure 1 presents the core architecture of IDont. Using this framework, an instructional designer creates a specific course by creating/selecting, adapting and using existing repositories of learning designs, learning objects and other
resources. Initially, the goals that are specific to the course are created and then the process for achieving these goals has to be selected. This can be taken from existing learning design repositories where well known instructional processes like problem-based learning, inquiry science abduction can be chosen followed by selecting the right set of learning objects/content. While there is criticism on reuse of learning objects, we believe that the right set of abstractions and systematic approach to modeling will give more benefits than disadvantages. In the next part of this section, we briefly explain the core ontologies of IDont framework.

A. Context Ontology

This is a meta-ontology that essentially captures the contextual knowledge related to a particular learning situation and has pointers to all other ontologies enabling their (re)use. While this is similar in spirit with LOCO ontology [9], we articulate context in a broader view. As shown in Figure 1, ContextOntology has contextual metadata and specifies how a ProcessContext achieves its goals using ContentContext through EnvironmentContext following EvaluationContext and performed by RolesContext. This systematic way of capturing knowledge allows assembling of specific course from content originated in different contexts.

B. GoalsOntology

This ontology formalizes the notion of goals (which can be instructional or learning goals). The details of how these are defined are left to teachers/instructional designers. Some properties associated with goals are hasName, hasPriority, hasPrerequisites, hasEvaluation, isAchievedByProcess. The GoalsOntology points to the process through which these goals will be achieved, target competencies, the instructional material that is required and the evaluation to be performed. Separating modeling of goals and its related evaluation using GoalsOntology allows teachers to reuse both of them.

C. Process Ontology

The crux of IDont framework is the ProcessOntology that captures the ID process and relates to other ontologies and practically executes the process. In the literature, learning design and in particular IMS LD received both significance and criticism [6]. Ontologies for modeling IMS LD are presented in [5]. Based on our prior experience with adult literacy instructional design, IPCL and our goal to introduce reasoning into adult literacy, we proposed a process framework called as pasti for plays, acts, scenes and instructions. Each lesson is like a play with teaching objectives, like the moral of a story, prologue and epilogue of the play explain the need of the objective, and exemplify its usage. To achieve the objective, the lesson is divided into sections, as the play is divided into acts and the lesson’s objectives are divided into sub-goals. An act, which coheres towards its sub-goal, is further divided into scenes, each having its own goal, and collectively leading to the assertion of the sub-goal of the act. Finally, the goal of the scene is collectively realized via subservient instructions, with each instruction deriving its strengths from observable facts, applicable deductions and inferences. An instruction is where the actual work of teaching is undertaken, plays, acts, and scenes are conceptual organizational structures. They provide convenient points in instruction for conveying motivation to learn, inspirational messages, exercises and so on. This instruction actually points to ContentOntology and associates required content for the respective instruction. This nomenclature allows us to systematically capture the knowledge of ID process and also to reduce technological effort. This hierarchy is similar to IMS LD but has some variations to align with adult literacy instruction.

D. ContentOntology

This ontology allows for modeling of instructional material in a particular learning situation. There is extensive research on ontologies for learning objects and we use the ALOCoM ontology [8] as the base for our framework. However, for adult literacy instructional design, we are experimenting with the use of the fcrtt (facts, cases, rules, models, and theories) structure, intuitively derived from scientific method, as a framework for preserving the content as data. So the ContentType of ALOCoM now includes fcrtt. The ContentOntology is closely associated with other ontologies and mainly with ProcessOntology.

E. EvaluationOntology

The main intent of this ontology is to capture evaluations as independent knowledge and link them with goals through ContextOntology. This separation makes it easier to perform different kinds of evaluations for the same set of goals. This ontology captures the details of evaluation and has a direct relationship with GoalsOntology and ProcessOntology.

F. Environment Ontology

This ontology allows separation of environment from the rest of ID and makes it easier to run the learning situation in different environments similar to software deployment.

Figure 1. Core Architecture of IDont modeling framework.
G. Domain Ontology

This ontology mainly articulates and customizes key aspects of ID through domain specific information. In particular, the various sub-ontologies and properties of these ontologies will have detailed associations when mapped to a specific domain. For e.g. the Content Ontology will have strong co-relation and mapping with content in the domain.

There are several other ontologies in IDont like Activities Ontology, Organization and Resources Ontology and so on to capture other aspects of ID. Due to space constraints, we are not elaborating detailed properties of these ontologies. However, the main intent of this paper is to present a separation of concerns approach to systematically capture different aspects of ID using ontologies while remembering that facilitating learning is the ultimate goal than reuse. As IDont framework originated from the practical needs of adult literacy problem in India, we summarize the details of its application to adult literacy problem in Figure 2.

IV. CONCLUSIONS & FUTURE WORK

Designing technology for adult literacy in India is a unique and complex research challenge because of large scale and variety (287 million in 22 Indian Languages) and the need for a unique learning methodology for teaching adult illiterates. In this paper, we have initially discussed the adult literacy case study and listed the major challenges of current technological aids for adult literacy. We emphasized the need for separation of concerns approach and presented the IDont framework to systematically model different aspects of ID as a way to explicitly capture adult literacy instructional design knowledge. We then discussed the core architectural and modular ontologies of IDont (Section III) followed by the application of IDont to adult literacy. We are currently designing a technology platform to support IDont and model different aspects of ID. We strongly believe that IDont is applicable beyond adult literacy to schooling as witnessed through arithmetic component in adult literacy.

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