CONCEPT-DRIVEN LEARNING GOAL FOR FLEX-EL

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ABSTRACT
There are a number of universities offering course material through elearning or web-based learning. The common practice is that these courses are available only for those learners who are seeking degree curriculum. Considering these rich educational resources, an approach that allows them to be utilized for supporting other types of learners, and allow such content to be managed from a single source of material would be very useful. In this paper, we propose concept-driven learning goal approach that allows these courses to be easily organized for personalized learning support, and manage from a single source of material. We then present a simple approach for personalized recommendation functionality based on the proposed representation using compulsory, elective requirements, and learner profile as the guiding parameters.

KEYWORDS
E-learning, concept-driven, compulsory, elective, learner profile, personalized recommendation

INTRODUCTION

The aim of distant learning services is to provide educational services to those who are living in the remote areas, too great of a distance to travel to the classroom where learning materials are delivered via the posted mail to these areas. In a short amount of time, educational providers are beginning to receive requests from those who are unable to attend the classroom for other reasons such as conflicting work-schedule. In another words, requests for distant learning services are now came from everywhere. The distant learning services are no longer just for those with geological constraint but also for those with time constraint.

The next evolution of distant learning really started with the introduction of the internet, institutions now have a new medium to deliver educational services. With this new medium, institutions can provide educational services at any time and any place. Educational services offering through the new medium is universally termed as elearning. With a number of tools available through the internet, learners and educational providers' expectations from elearning are quite substantial. Some of these expectations can be observed from a number of attempts to describe elearning. A few of these attempts are given as follows.

- The uses of network technologies to create, foster, deliver, and facilitate learning, anytime and anywhere.
- A phenomenon delivering accountability, accessibility, and opportunity to allow people and organizations to keep up with the rapid changes that define the Internet world
- A force that gives people and organizations the competitive edge to allow them to keep ahead of the rapidly changing global economy
- The delivery of individualized, comprehensive, dynamic learning content in real time, aiding the development of communities of knowledge, linking learners and practitioners with experts

In the early days, systems that use to deliver elearning are basic software applications allowing learners to access the educational contents stored in the system based on information systems. We will refer to such systems as elearning systems.
After rapid rising since its berth in the early 1996, interests in elearning begin to drop significantly as illustrates in Figure 1. Consequently, elearning providers begin to realize that more works must be done in developing content for elearning environment. This leads to the beginning of elearning content development research area where the aim is to develop education content specifically suitable for internet environment.

Content development played a key role in e-learning (Jegan 2004), the growth in elearning content development research allows challenging possibility of better and more advance learning functionalities for learners or elearning providers to be considered. Consequently, various elearning research areas begin to emerge such as authoring tools development, content and learner management, and content standard development.

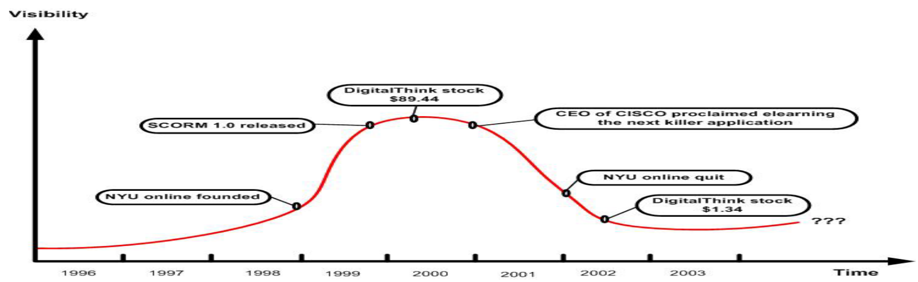

Figure 1. The elearning Hype (Kruse 2002)

Eventually, elearning development paradigm begins to shift toward changing behaviours of the system to meet requirements of each learner. We have coined such systems as personalized elearning systems, PeLs. There are a number of researches which had lead the way toward PeLs (Browne, Totterdell et al. 1990; Brusilovsky 1995; Brusilovsky, Schwarz et al. 1996; Kay and Kummerfeld 1997; Vassileva 1997). In the literature, there are no clear-cut classifications of personalized elearning systems. One manner to classify such systems is through the functionalities they provide.

The *Personalized path* systems provide each learner with learning activities, which are sequenced at time of delivery depending on specified behaviours and the learner's actions. Personalized path systems have also been referred to as curriculum sequencing system. (Brusilovsky 1999) The personalized path systems typically require human experts to design possible paths in advance. Each learner can then be guided intelligently toward the sensible pre-designed path during the runtime.

Vassileva's (Vassileva 1997; Vassileva and Deter 1998) works involves dynamic planning of the contents of an instructional course with a given goal. The main idea of this system is to apply artificial intelligent planning techniques to determine suitable content of instruction. The core of the work is domain structure concept where structure of each subject is represented as an AND/OR graph, and classical artificial intelligent mechanisms for planning from the graph.

(Melis and Meier 2000) proposes system that not only provide adaptive course generation but also adaptive presentation functionality as well. Flex-eL (Marjanovic and Orlowska 2000; Lin, Ho et al. 2002) using workflow principles to facilitate personalized activities sequencing. The motivation behind their work is providing a learner-centric learning system instead of lecturer or curriculum centric learning system. Stern's work (Stern and Woolf 2000) attempts to integrate personalized instructional sequencing to an online lecture system by providing adaptive activities to the learners. Another system trying to integrate personalized Instructional sequencing to an online lecture is (Chan, Cao et al. 2001). His work focuses on providing learning system that could facilitate self-paced learning for the learners.

The *Personalized support* systems provide instructive support for learners at the time of delivery depending on specified behaviours and the learner's actions. The works in this area involve automatically analysing learners' answers to identify the missing knowledge or the incorrect knowledge responsible for the incorrect answer, and then inform the learner for correct answers and provides correct information for incorrect answers.

One of the earliest systems offers interactive problem solving support is the LISP-TUTOR (Anderson and Reiser 1985) which was developed to teach the basic principles of programming in LISP. In the LISP TUTOR, the expert model is a series of correct production rules for creating LISP programs while learner model is a subset of these correct production rules along with common incorrect production rules. It builds around the concept of learning by doing where the learner discovers the productions while working through problems. ELM-ART (Brusilovsky, Schwarz et al. 1996) proposed ten years later has interactive problem solving support that aims to provide intelligent help (hints etc.) to guide learners to the right answer on each step of the problem solving.

Taking a different approach, Intelligent Helpdesk (Greer, McCalla et al. 1998), develop by University of Saskatchewan group, focuses on physical information collected from learners. It identifies learners that might need particular assistance based on parameters assigned such as progressing rate, material access rate. The idea is to constantly check on each learner's performance and thus be able to provide assistances just in time. Another system is the HyperClassroom (Oda, Satoh et al. 1998) which aims to identify deadlock learners in an e-learning classroom. The system measures similarity of learning activities of learners to determine if learners are experiencing gridlock in learning.

The *Personalized presentation* systems provide learners with content presentation that is most suitable to his/her cognitive learning capability at the time of delivery depending on specified behaviours and the learner's actions. The work in this area has also been referred to as Adaptive Hypermedia (Brusilovsky and Peylo 2003).

(Kay and Kummerfeld 1997) presents an approach that involves using user model to provide learners with customized hypertext. Her work involves creating user model that use to specify customized hypertext for each user. Another work in this area is the Adaptive Hypermedia Architecture, AHA! (De Bra and Calvi 1998, De Bra, Aerts et al. 2000).). The goal is to support an on-line course with some learner guidance through conditional explanations and conditional link hiding.

We have shown that there are a number of interests in the PeLs development, and there are a number of possible directions to pursue. In this paper, we are investigating extending Flex-eL's functionality to support broader range of learners. We classify Flex-eL as a personalized path PeLs as its aim is to provide personalized learning path by allowing learners to adjust time and learning path to meet individual needs. We begin by examine the Flex-eL. Flex-el organises content in the educational repository using various subject granularities to support the concept of flexible learning pathways. These subjects are consisting of modules that are managed by a number of learning activities. The study guide enables effective integration of various learning activities while workflow technology offers the right task i.e. learning activity at the right point of time to the learner along with learning resources needed to perform these tasks.

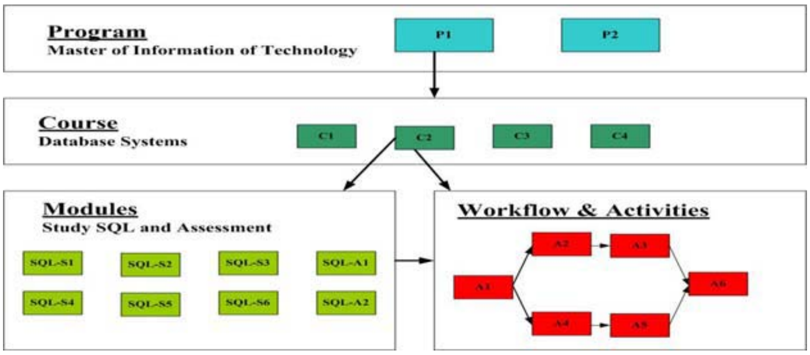

Figure 2. Flex-el Structure

Figure 2 shows course structure offered in Flex-eL mode. Each program is composed of a selection of courses, and each course is composed of a set of study and assessment modules. In the traditional approach, modules within a course are taught sequentially, one after another. But in Flex-eL, courses can be designed in a way so that modules can be performed paralleled or sequentially. Thus, it is possible for learners participating in the same course to have different path for completing the course. This path is defined as the learning pathway. This is a more flexible way of learning since each learner can decide his or her suitable learning pathways. Consequently, the course modules are designed into a workflow process to contain a number of study and assessment activities. Figure 3 shows the Flex-eL's approach which extends the typical e-learning approach by keeping the necessary collaboration tools, plus assigning each learner an individual learning process driven by workflow, so that the entire learning process can be monitored and guided.

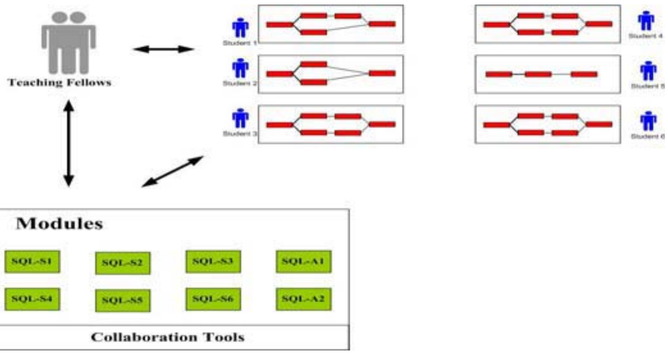

Figure 3. Flex-el Approach

There are a number of needed improvements if Flex-eL is to be extended to support broader types of learners. First, a more flexible approach in the manner that Flex-eL organizes the content in the educational repository is needed. The new approach must not only support degree-seeking learners but also can support other types of learners such as work related training learners as well. Second, mechanism to facilitate personalized inferencing or navigating through content in the repository would allow learners to explore available content effectively and efficiently. Third, mechanism for automate learning support for learners could be a valuable useful improvement for Flex-eL. While it might not be possible to design automate learning support to replace human involvement, there are a number of manners that such automate supports can be useful when human interactions are not available. For example, consider substantial number of courses and theirs complex relationships available, an automate consultation mechanism that that assist learners in keeping track of his/her progress or help recommend sensible courses to enrol would be quite useful.

One of the approaches toward providing personalized learning functionality is the use of explicit organizing of desired knowledge, which we call goals. In this paper, we present concept-driven learning goals approach to organize Flex-eL educational content. Method for generating these goals and heuristics for selecting among potential inferences to provide personalized learning material are also discussed. In this manner, personalized learning functionality becomes a kind of planning: decision about what to infer, how to infer, and even when to infer based on representation of desired knowledge. We aware that solution for organizing content is application dependent, and there will never be a single best solution to organize these courses. Our goal is to organize knowledge in the repository of Flex-eL that are currently suitable only for learners who are following ITEE guideline such that they would allow Flex-eL to provide support for broader types of learners by:

- Allow system to facilitate personalized learning material.
- Allow system to provide easy exploration of the available courses.
- Allow system to provide automate consultation regarding personalized goals recommendation

The paper is organized into two parts. The first part discuss concept-driven learning goal. Requirements and constraints such as compulsory, elective, prerequisite are also discussed in the first part. The second part illustrates potential use of the concept-driven learning goal for personalized goal recommendation.

CONCEPT-DRIVEN LEARNING GOAL

Learning is the process of acquiring knowledge or skill through study, experience or teaching. In this manner, we could view such process as a personal journey from one destination to another. It is often that a trip from one to the other cannot be done in a direct manner. For example, to reach a particular destination, it is possible that several related destinations must be first visited, and often in a particular sequential manner.

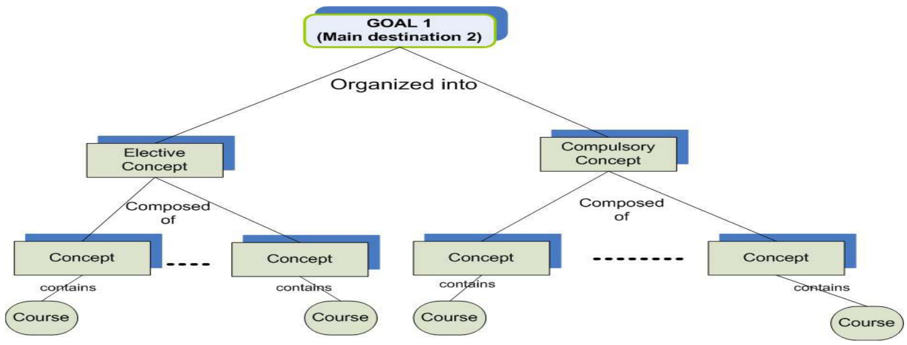

Figure 4. Concept-driven Learning Goal

The idea of concept-driven learning goal illustrated in Figure 5 stems from this observation. We organize courses into several groups of smaller destinations called concepts, and then organize these groups of concepts into main destinations called goals as illustrates in Figure 6. In this manner, we are able to guide each learner based on reasoning about the information that needed to reach the desired destinations. We begin by first giving necessary definitions.

Course: is composed of a specific study module or grouping of study modules that once completed will lead learners toward acquiring skills that are necessary to reach a particular goal where each course is unique and each study modules are stored in digital format and is the smallest granularity.

Concept: is defined as a composition of courses as elements and theirs combination. The experts arrange the composition to teach a particular skill such as circuit design or basic programming skill. Note that it is common to have two or more goals sharing a number of concepts.

Goal: is defined as complex composition of concepts as elements and their combinations. The composition is arranged by the experts to meet a particular learning outcome such as for bachelor degree in electrical engineering.

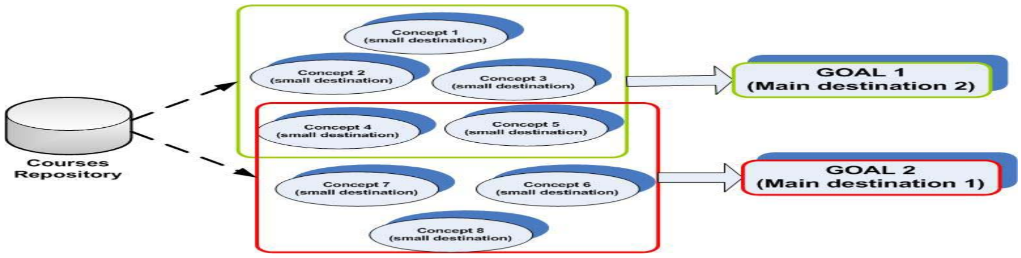

Figure 5. Concept-driven learning goal

There are a number of relationships between goals, concepts, and courses, and in order to help us identify such relationships, we will continue with the travelling analogy. If the people of Tuscany region are asked about the provinces that one should visited, they are most likely will tell you that all the provinces in Tuscany must be visited. However, given time or financial limitations, this might not be the most sensible solution. In this case, after a controversial discussion among the Tuscan, a group of provinces is assigned as a compulsory destination while the rest are categorized into various groups of elective destinations such as group of red wine, group of white wine etc. In the same manner, for consider a particular goal, travelling to Tuscany region; educational experts can assign concepts i.e. provinces, into compulsory and elective concepts as illustrates in Figure 7. The role of compulsory concept is to ensure that learning will be coherent and balance, and that all the necessary concepts are studied. We define compulsory concept as a set of concepts that must be studied and passed in order to complete the requirements of a particular goal. On the other hand, the role of elective concept is to provide learners with ability to tailor his/her learning. For example, one elective concept might be designed to provide learners with additional skill in management while the other might be designed to provide learners with additional skill in law. We then define elective concept as a set of concepts that learners can choose to enrol, which, when added to the compulsory concept, enable requirements of a particular goal to be met. Note that the requirement relation can also be introduced at the concept level. Furthermore, at the concept level the expert might choose to assign compulsory courses and elective course as requirements of a given concept.

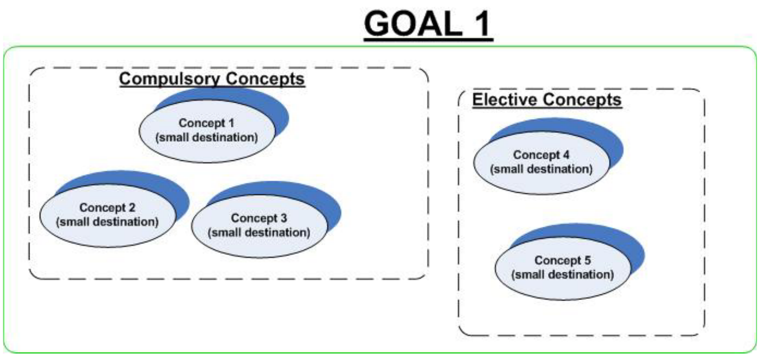

Figure 6. Compulsory and elective concepts

Not only how these destinations should be visited is very important but also when to travel to these destinations is very important. If there is a list of destinations that one would like to visit, it is important that one should know when would be the best time to visit these destinations. In many case, it is even more important to know when the destinations cannot be visited. In the same manner, it is crucial for learners to know when these concepts cannot be visited.

One relationship that is normally used to describe when a concept can be visited i.e. enrol is called prerequisite relation. Prerequisite relation allows expert to specify how goals, concepts, or courses can be visited. Note that prerequisite relation is applicable at any granularity level. For example, if entity_1 is a prerequisite of entity_2 then entity_2 can be visited if and only after entity_1 had been visited. Prerequisite relations can be illustrated as two connected entities where the arrow signifies the direction of prerequisite relation. The entity at the tail of the arrow is prerequisite of the entity at the end of the arrow as illustrate in Figure 8.

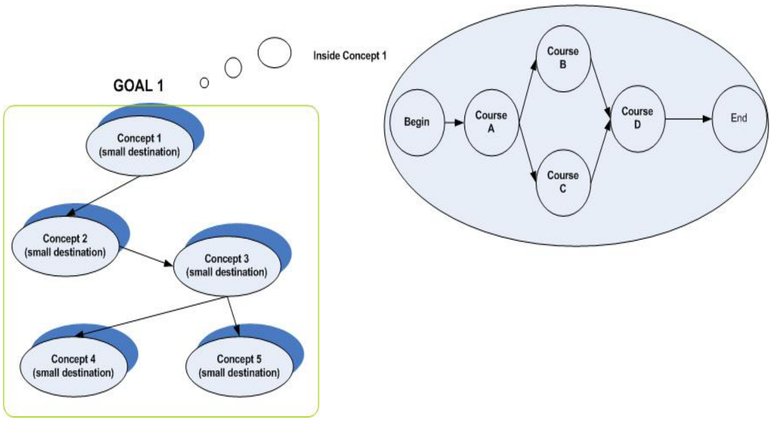

Figure 7. Prerequisite relation at the concept level and at the courses level

Goals, concepts and courses can be described by its properties as illustrated in Figure 9. There a number of properties i.e. attributes that can be used to describe these goals. Examination of these attributes revealed four general classes of attributes useful for discovery and retrieval goal. These common classes are summarized as follows:

- *Audience*: A broad class of learners containing various attributes describing characteristics of the targeted learner for the given goal
- *Duration*: Information denoting the normal "study" time requires for completing the goal
- *Learning Characteristics*: Information denoting activities or method used by an instructor or trainer including those stemming from various educational theories, student groupings, and assessment methods to design the goal
- *Competencies*: Information denoting the related skills and behaviour needed to complete the goal successfully.

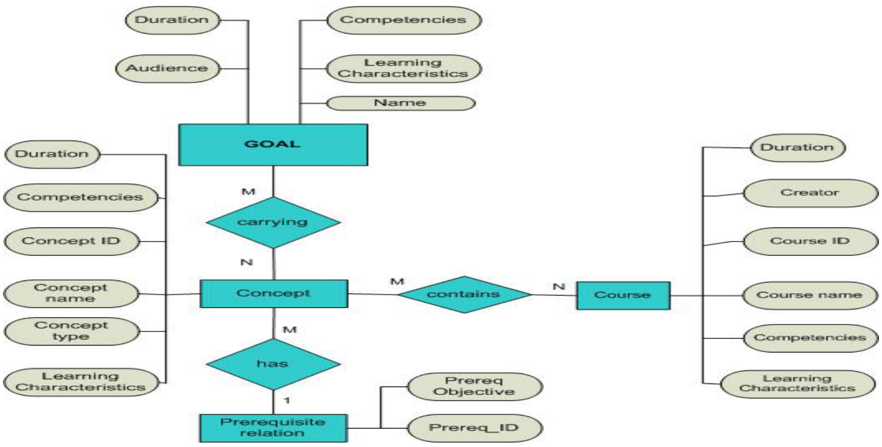

Figure 8. Goal Model

Consequently, by organized educational content in this manner, lecturers and course-designers can reused the educational content in different configurations to offer richer selections to match the needs of the learners. Thus, enable Flex-eL system to support broader types of the learners. Furthermore, there are a number of manners that compulsory and elective requirements can be utilized for various pedagogical designs. For example, course designers might want to provide learners with several versions of a given concept. He/she can specify a novice version, intermediate, and expert versions of a given concept where novice version contains relevant fundamental courses related to the concept.

CONCEPT-DRIVEN LEARNING GOAL FOR PERSONALIZED RECOMMENDATION

In this paper, we limit our discussion to a simple pedagogical design where a concept has only one group of elective courses. We also like to point out that background verification and online assessment issues will not be discussed in this paper. In this part, we will illustrate that the introduced concept can be utilized to provide Flex-eL with personalized goals recommendation functionality.

We have observed that even though it is convenient and easy to access elearning content, it is not a trivial undertaking for learners to determine courses to enrol unless they are willing to follow strict institution's guideline, or they are quite familiar with these courses. This is due to the considerable large number of courses, complex requirements, and constraints that exist in any learning institutions. Furthermore, getting assistances in elearning environment is not as straightforward as in the traditional classroom where face-to-face consultation is normal and peers are easier to be found. In this part, we discuss how the proposed structure can be utilized to extend the scope of Flex-eL services by providing functionality, which will deliver smart and automate consultation mechanisms for recommending goals. The function ensures that the recommendation is both coherent and sound for each learner by checking compulsory and elective requirements against background of the learner.

The function operates as follows. Each time learners need to acquire new learning activities, he/she can activate the function. The function then checks if the learner has an existing profile. For those who do not have an existing profile, the function initiates user dialog to acquire the profile. Once the profile is created, the function compares goals with each learner profile. The goals that relevant to the learners are identified. We call these goals as candidate goals. A number of parameters that can be used to identify a set of candidate goals for each learner such as keyword, level of difficulty, and goal's outcome but in this paper, we utilize a set of completed courses acquired from learner as our key parameter. In this manner, we ensure that learners will always have adequate background in any goal he/she decides to pursue.

There are a number of possible ranking schemes for recommendation purpose. For example, some learners might like to be recommended only courses that are not related to courses he/she have already completed. In this paper, we propose a useful ranking scheme based on minimum remaining number of courses to complete in conjunction with the maximum number of completed courses that can be retained.

Goal

Let a set of non empty finite courses available in the system be denoted as $D = \{c_1, c_2, \ldots, c_z\}$ where each element in D is unique and composed of a specific study material or a group of study material and $I = \{1, 2, \ldots, z\}$ is a set of identifier for element in D.

We begin by associate two sets of courses in D to form a fundamental basis composition of a goal. In this manner, the task of course designer is to select from these two sets to compose a goal. We called the first set compulsory requirement courses denoted as *Compulsory* = $\{c_i, i \in I \mid c_i \in D\}$ and chosen by the expert}, and called the second elective requirement denoted as $Elective = \{e_j, j \in J \mid e_j \in 2^D$ and chosen by the expert$\}$.

For each goal, learners are required to complete courses in some consecutive order specified by prerequisite and corequisite constraints. We define prerequisite constraint as a set of ordered pairs denoted as $\Pr erequisite = \{(c_u, c_v) \,|\, \text{chosen by the expert where } c_u, c_v \in D \, and \, u, v \in I$ such that c_u is a prerequisite of c_v and the completion of c_u is required before c_v can be enrolled$\}$.

Note that not all the compulsory courses, elective courses, and prerequisite combinations are pedagogical sensible, thus it would not be sensible to allow learners to compose these combination themselves. Consequently, in our work we will assume that each possible combination must be selected by the expert in advance. We then define each goal as a unique combination of requirements and constraints selected by the expert denote as *G*. For identification of each goal, we denote a set of goals as $\Pr ogram = \{G^1, G^2, ..., G^s\}$ where $O = \{1,2,...,s\}$. Consequently, we can express a given goal as $G^g = (Compulsory^g, Elective^g, \Pr erequisite^g)$ where $g \in O$.

Learner Profile

Various learner's attributes can be use to determine sensible recommendation. In learning environment, learner's background knowledge stood out as a very sensible attribute when consider learning activities recommendation. Each learner is represented by the courses that he/she had completed. Note that there must be some mechanism for verification of these completed courses but it is not in the scope of this paper. We will assume that all the completed courses can be accurately acquired from each learner.

We then denote a set of non empty finite learners profiles stored in the system as $Learner = \{L^1, L^2, ...L^t\}$ where $S = \{1,2,3,..p,..,t\}$ be a set of identifiers for elements in *Learner*. Note that any possible sets of courses deemed completed must be a member of the set 2^D. In another word, 2^D is the domain of completed courses. For our application, we can then represent learner, L^s, by a set of his/her completed courses and denote as $Completed^S = \{c_i, i \in I \,|\, c_i \in D, \text{and acquired from the learner, } L^s\}$

Candidate Goal

We only considered goals that could be interesting to a given learner. We call this as candidate goals. There are a number of parameters used to identify a set of candidate goals such as keyword, level of difficulty, and goal's outcome. In this paper, we utilize a set of completed courses acquired from learner as our key parameter. In this manner, we ensure that learners will always have adequate background in any goal he/she decides to pursue. We denote a set of candidate goals for each learner as CG^s. For any $G^g \in \Pr ogram, g \in O$ to be considered as a candidate goal for a given learner, L^s, one of the following conditions must be satisfied.

1. $Compulsory^g \cap Completed^s \neq 0$
2. $Elective^g \cap Completed^S \neq 0$

Minimum remaining Maximum retaining Ranking Scheme (MrMr)

For recommendation, candidate goals can be ranked either based on learner's criteria, learner's background or both. We have chosen completed courses information that stored in learners' background as key index for ranking the candidate goals. There are a number of possible ranking schemes based on the completed courses of a given learner. For example, some learners might like to be recommended only courses that are not related to courses he/she have completed. In this paper, we propose a useful ranking scheme based on minimum remaining number of courses to complete in conjunction with the maximum number of completed courses that can be retained.

In **MrMr** ranking scheme, candidate goals are first sorted through smallest number of compulsory courses remaining. The sorted candidate goals are then sorted by the smallest number of elective courses remaining, and follow by the maximum number of cardinality of compulsory courses. The second sorted candidate goals are then last sorted by the maximum number of cardinality of elective courses. Note that it is also possible to refine the ranking by also consider prerequisite constraint of the given goal such as the number of prerequisite courses, however, this is not in the scope of this paper.

Let the number of uncompleted compulsory courses of a given candidate goal, G^s, be denoted as $Un\_comp^s = | Compulsory^g \cap Completed^s |$. Let the number of uncompleted elective courses of a given candidate goal, G^s, be denoted as $Un\_elec^s = | Elective^g \cap Completed^s |$. We then define preferences ranking as follows.

G^s and $G^t \in CG^s, G^s$ is said having higher ranking than G^t denoted as $G^s > G^t$ iff

1. $Un\_comp^s < Un\_comp^t$;
2. $Un\_comp^s = Un\_comp^t$ but $Un\_elec^s = Un\_elec^t; or$
3. $Un\_comp^s = Un\_comp^t, Un\_elec^s = Un\_elec^t \; but \; | Compulsory^s | > | Compulsory^t ; or$
4. $Un\_comp^s = Un\_comp^t, Un\_elec^s = Un\_elec^t \; but$
   $| Compulsory^s | = | Compulsory^t |, | Elective^s | > | Elective^t |$

There are a number of situations where two candidate goals can be considered equivalence after the MRMR ranking; we introduce another definition to deal with such situation. Note that it is possible to do more complicate comparison based on other parameters such as competencies or objective properties but it is not in the scope of this paper.
G^s and $G^t \in CG^s, G^s$ is said indifference from G^t denoted as $G^s \approx G^t$ iff

1. $Un\_comp^s = Un\_comp^t, Un\_elec^s = Un\_elec^t \; but$
   $| Compulsory^s | = | Compulsory^t |, | Elective^s | = | Elective^t |$

CONCLUSION

We have presented concept-driven learning goal approach to organized courses in the Flex-eL repository. The representation allows Flex-eL to provide support to a broader range of learners using one source of material in the repository. We then illustrate a simple recommendation functionality that can be implemented based on the representation. We aware that in many instances the minimum number courses left uncompleted might not be adequate for providing unique solution for the learner. Consequently, other parameters must be utilized to help refine the inferencing process.

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