WEB SERVICE TECHNOLOGY FOR DISTANCE AND OPEN LEARNING

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ABSTRACT

In any distance and open learning system, the following functions are mandatory: Content Authoring/Acquisition, Structuring of content (logic and format), storage, processing, distribution and access. How these are done will determine the nature and effectiveness of the system. In turn these are dependent on what the purpose of the system is and how it is to be used. In many modern e-learning systems, these are not clearly defined and we find, very often, that the pedagogical design objectives of a course of study and its purpose are poorly met, even when the presentation of the contents are excellent. They are usually also of the one size fits all type, i.e. they are not flexible and assume all learners are the same and do not cater for learning styles and personal differences in ability of the learning community. In this paper we report a prototype system based on a framework which enables course and content designers to develop personalized learning systems which are important for distance learning where the availability of personal help from teachers and instructors may be poor.

Keywords: *e-learning, pedagogy, personalized learning, education reform, concept maps, framework design*

1. INTRODUCTION

Advances in highly interactive computing technology now makes it possible to realize personalized learning. Modern e-learning systems need to continually probe the learner, find out at that instant what he wants to know, and what he can and cannot do. Based on this dynamic gathering of information and taking his pre-defined learning preferences and constraints into considerations, the modern e-learning system must then be able to offer personalized support and learning solutions in real-time. Such an approach combines real-time assessment, learning, and pedagogical considerations into one seamless learning activity. Unfortunately, although such an approach can address and assist with individual learning problems, few learning solutions of such a nature exist. Sadly, in spite of the tremendous advances of technology and growing economic demands for better trained manpower, our educational systems have not responded at the same pace. The major learning modes remain unchanged. As emphasized in the earlier research papers [1, 2], our current utilization of technology and pedagogical principles are still far from what is needed, for all that plagues our under-performing educational sector. With easy access to the World Wide Web, interactive media technology and facing the challenges of a fast-paced global economy, 21st century students are now demanding more flexibility and control in taking responsibility over their learning. Gone are the days where students follow a full training course and treat lectures or textbooks as their primary course of learning. 'Fragmented learning' or learning-on-demand is becoming the new trend of learning for the 21st century students. In this paper, we identify some major new trends in learning. In doing so, we identify some vital issues which expose the weaknesses in today's e-learning systems. Through this, we are then able to develop a novel learning framework which enables us to address the weaknesses we have identified. Through this framework we can streamline the educational process into one seamless learning activity that integrates personalized assessment with learning. We advocate that such an approach is important to help course and content designers to develop personalized learning systems – an important aspect of distance learning where the availability of personal help from teachers and instructors may be poor.

This paper is organized as follows: following this introduction, we look briefly at the evolution of e-learning and identify new requirements in learning in the 21st century. Next, we discuss how these requirements can be met by streamlining the educational process into one seamless learning activity that integrates personalized assessment with learning. The fourth section illustrates our proposed solution, using a system we have developed. Lastly, this paper concludes and suggests ideas for future work.

2. EVOLUTION OF DISTANCE LEARNING

The face of education in the 21st century is changing rapidly. With the invasion of PCs, the Internet and Web technology into almost every walk of life, it is not difficult to understand why educationalists have reached a universal belief that the use of this technology is essential for today's learning. Labeled as e-learning, this has evolved from small individual efforts into a well-defined, dynamic and technology-centered form of learning technology. A brief look at the evolution of e-learning follows.

As the Web evolved, training providers began exploring how this new technology could improve training. Accessibility to this form of training, related by Hall [3], is through the use of browsers such as Internet Explorer or Netscape Navigator. Web-based training typically includes methods such as: streaming audio and video, hyperlinked Web pages, live Web broadcasts, and portals of information – and/or interactive methods – such as: bulletin boards, chat rooms, instant messaging, videoconferencing and discussion threads. The instructions can be facilitated and paced by the trainer or self-directed and paced by the learners.

The next generation of Web will be characterized by the social networking paradigm, built upon Web 2.0. Similar to learning, Web 2.0 will be about people, not technology. We believe that we already have the necessary technology at our fingertips. The next generation of e-learning will, hence, build upon these technologies to enhance the user learning experience that stem from Web based communities and hosted services such as social networking sites, Wikipedias and folksonomies to facilitate learning collaboration and exchange of ideas and information between users.

3. STREAMLINING THE DISTANCE-LEARNING PROCESS

There is still a significant gap to fill before we can make use of the social networking paradigm for learning exchanges in the 21st century. To be able to effectively share and exchange intellectually, the person must first be equipped with basic competencies on the subject matter. However, current major modes of imparting competencies are still poorly structured and centered on the use of lectures and textbooks (often uploaded into an e-learning system and called e-learning). Such modes provide little personalization and often, the pedagogical design objectives of a course and its purpose are poorly met, even when the presentation of the contents are excellent. Also, they are usually of the one size fits all type, i.e. they are not flexible and assume all learners are the same and do not cater for learning styles and personal differences in ability of the learning community. More importantly, the concept of assessment, employed in e-learning, is being used in a limited way. Currently, assessment is used mostly as a form of grading – either as a pre-course or post-course grading mechanism. Although the pre-course assessment is targeted to assess the learner's existing knowledge level so as to help deliver the course in a way that best suits the learner, no form of courseware personalization is being employed. Currently, regardless of how the learner fares in his pre-course assessment, the same type of learning material and sequence will be presented. Hence, the current form of pre-course assessment is used only as a form of comparative standard of measurement (knowledge level before and after course) and not as a form of learning content and sequence personalization. Current approaches also fail to apply cognitivism and constructivism principles that place great emphasis on prior knowledge. Hence, most learners are unable to connect with the learning content. A more effective learning approach would be to personalize the courseware to start off from the learner's prior knowledge using results from the pre-assessment. Such an approach enables the educational process to be truly personalized with continuous assessment and learning. We believe that this approach conforms to cognitivism and constructivism concepts and promotes effective knowledge transfer.

4. PROPOSED PEDAGOGICAL DESIGN

As opposed to current learning approaches of treating learning, assessment and pedagogical content design and structuring into separate activities, our solution acknowledges that learning is a dynamic process that must not only consider the subject matter being taught but also the prior knowledge of the audience and the dynamics of the learning environment. In order to streamline the learning activity to integrate personalized assessment with learning, the following pedagogical design considerations must be met: constructivism concepts and promotes effective knowledge transfer.

4.1. HIERARCHICAL CONTENT STRUCTURE

The size and scope of the learning resources is a key pedagogical consideration. Besides the issue of network delivery, the learning resource structure also affects the pedagogical nature of learning. For example, if the learning course contains only a few large-grained learning resources, then re-sequencing to form a new course to support a different pedagogical/personalization approach may not be possible. On the other hand, although smaller grained learning resources are more flexible, the assembling of many fine-grained learning resources may require a considerable effort to tailor the narrative flow of the course to make sense in the context of learning. While many researchers propose defining granularity in terms of the learning resource's file size or semantic density (as defined by LTSC Learning Objects Metadata Working Group), estimated learning time (Wisconsin Online Resource Center), or complexity level per learning setting, such parameters are inappropriate. This is because no two learners learn at the same pace or perceive things in a similar fashion. Furthermore, the specific learner profile is often not available at the conception of the course. Hence, such a granularity assessment is difficult to justify. So, with what criteria can we use to generalize the learning time or complexity level for a group of learners?

Here, we propose designing learning resource granularity based on learning concepts. A learning concept is the most basic form of learning and is used to convey paradigms of information. It covers concepts (e.g. "What is a Router?"), facts (e.g. "Water is made up of hydrogen and oxygen atoms") and principles/laws (e.g. "Newton's Three Law of Motion"). These are the most fundamental learning things that must be mastered first before more complex learning events or outcomes [i.e. procedure (e.g. "How to set up a router"), process (e.g. "How traffic flows in a network")] can be learned, based on a four-dimensional (active/reflective, sensing/intuitive, sequential/global, visual/verbal) learning style model. Relationships between courses must also be specified to enable concept mapping. Expertise Levels – Novice, Intermediate, Expert Detail Levels – Overview, Normal, Detailed Presentation Formats – ILS (Active/Reflective, Visual/Verbal, Sensing/Intuitive, Sequential/Global) Relationships – Associate, Essential Pre-requisite, Supplementary Pre-requisite, Augment Post-requisite, Utilize Post-requisite

4.2 COURSE DESCRIPTION LANGUAGE

The metadata of the learning resources follow the Dublin Core Metadata Element Set, Version 1.1 and is meta-tagged using the 15 elements namely, Title, Creator, Subject, Description, Publisher, Contributor, Date, Type, Format, Identifier, Source, Language, Relation, Coverage and Rights. A separate Course Description Language (CDL) is also tagged to the learning resources to enrich the metadata and to allow conceptual mapping. Through CDL, the pedagogical and personalized considerations can be achieved. The root element of CDL is the <course> element. The usage of the term, course, gives no indication of the hierarchical level of the learning resource. The <information>, <structure> and <lconcepts> element are the child elements of <course> (fig. 1).

```
  <?xml version="1.0" encoding="UTF-8" ?>
- <course>
  + <information>
  + <structure>
  + <lConcepts>
  </course>
```

Figure 1: CDL <course>

Information of the course will be stored in the <information> element. The <information> element is the parent of the <abtInfo> and <learningInfo> element as shown in Figure 2. The <abtInfo> element embeds administrative related information about the course and includes information such as the course name (<cName>), the identifier (<cID>), the author(s) (<cAuthors>), date created (<cDateCreated>), cost of accessing the course (<cCost>), storage location (<cLocation>), and the learning domain (<cDomain>). The <learningInfo> tag embeds learning-related information about the course and includes information such as the learning preferences adopted (<cLearningPref>), the complexity level (<cExpertise>), the level of details (<cDetail>), the hierarchical level (<cLevel>), the academic level (<cAcademic>) and the duration of the course (<cDuration>).

```
  <?xml version="1.0" encoding="UTF-8" ?>
- <course>
  - <information>
    - <abtInfo>
        <cName>Integration</cName>
        <cID>MTHST0001</cID>
        <cAuthor>admin</cAuthor>
        <cDateCreated>2006-04-30 21:18:05</cDateCreated>
        <cCost>48</cCost>
        <cLocation>http://www.ntu.edu.sg/MTH/TOPIC/S1/MTHST0001</cLocation>
        <cDomain>MTH</cDomain>
        <cAcademic>S</cAcademic>
      </abtInfo>
    - <learningInfo>
        <cLearningPref>0 -1 0.5 1</cLearningPref>
        <cExpertise>Expert</cExpertise>
        <cDetail>Normal</cDetail>
        <cDuration>2:00</cDuration>
        <cLevel>Topic</cLevel>
      </learningInfo>
    </information>
  + <structure>
  + <lConcepts>
  </course>
```

Figure 2: CDL <information> tag

The structure of the course will be captured through the <structure> element. This element is the parent of the <internal> and <external> element. The <internal> element embeds the next lower hierarchical granularity of learning resources. For example, a topic will have its internal structure made up by RLO while a RLO will have its internal structure made up by RIO. The name of the learning resources as well as its physical location is stored by the <RLO> element and <rloLocation> element respectively. The <external> element embeds the learning resource's relationships with other learning resources. Usually, the "related" learning resources will reside at the same hierarchical level as the main learning resource. For example, from Figure 3, as the main learning resource, MTHST0001, resides at a topic level, all the external courses also reside at the topic level. Similar to the <internal> element, the <external> element embeds the name of the learning resource and its physical location.

The <lConcepts> element contains the learning concepts and their weightage in the main course. For example, course MTHST0001 imparts the learning concept of integration by parts (30%), integration by substitution (20%) and integration techniques (50%) (fig. 4).

```
  <?xm version="1.0" encoding="UTF-8" ?>
- <course>
  + <information>
  - <structure>
    - <internal>
        <RLO1>MTHPR0006</RLO1>
        <rloLocation1>http://www.ntu.edu.sg/MTH/RLO/P6/MTHPR0006</rloLocation1>
        <RLO2>MTHPR0020</RLO2>
        <rloLocation2>http://www.ntu.edu.sg/MTH/RLO/P6/MTHPR0020</rloLocation2>
        <RLO3>MTHPR0022</RLO3>
        <rloLocation3>http://www.ntu.edu.sg/MTH/RLO/P6/MTHPR0022</rloLocation3>
      </internal>
    - <external>
        <cAssociated1>MTHST0059</cAssociated1>
        <assLocation1>http://www.ntu.edu.sg/MTH/TOPIC/S1/MTHST0001</assLocation1>
      - <cPreReq>
          <essential1>MTHST0004</essential1>
          <essLocation1>http://www.ntu.edu.sg/MTH/TOPIC/S1/MTHST0004</essLocation1>
          <essential2>MTHST0005</essential2>
          <essLocation2>http://www.ntu.edu.sg/MTH/TOPIC/S1/MTHST0005</essLocation2>
          <gdToKnow1>MTHST0007</gdToKnow1>
          <gtkLocation1>http://www.ntu.edu.sg/MTH/TOPIC/S1/MTHST0007</gtkLocation1>
        </cPreReq>
      - <cPostReq>
          <augment1>MTHST0011</augment1>
          <augLocation1>http://www.ntu.edu.sg/MTH/TOPIC/S1/MTHST0011</augLocation1>
          <augment2>MTHST0022</augment2>
          <augLocation2>http://www.ntu.edu.sg/MTH/TOPIC/S1/MTHST0022</augLocation2>
          <augment3>MTHST0032</augment3>
          <augLocation3>http://www.ntu.edu.sg/MTH/TOPIC/S1/MTHST0032</augLocation3>
          <utilize1>MTHST0010</utilize1>
          <utiLocation1>http://www.ntu.edu.sg/MTH/TOPIC/S1/MTHST0010</utiLocation1>
          <utilize2>MTHST0045</utilize2>
          <utiLocation2>http://www.ntu.edu.sg/MTH/TOPIC/S1/MTHST0045</utiLocation2>
        </cPostReq>
      </external>
    </structure>
  + <lConcepts>
  </course>
```

Figure 3: CDL <structure> tag

```
  <?xml version="1.0" encoding="UTF-8" ?>
- <course>
  + <information>
  + <structure>
  - <lConcepts>
      <concept1>By Parts</concept1>
      <weight1>0.3</weight1>
      <concept2>Substitution</concept2>
      <weight2>0.2</weight2>
      <concept3>Techniques</concept3>
      <weight3>0.5</weight3>
    </lConcepts>
  </course>
```

Figure 4: CDL <lConcepts> tag

4.3 SEARCH
BASIC SEARCH

Example: The learner wants to learn Algebra (weightage 0.4), (Integration) By Parts (weightage 0.2) and (Integration) Substitution (weightage 0.2), (Integration) Techniques (weightage 0.1) and Statistics (weightage 0.1) in Domain MTH (mathematics). The learner's request will be captured using the following form in Figure 5.

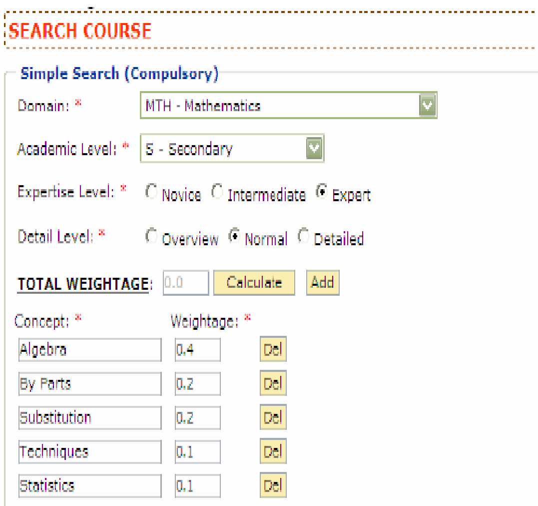
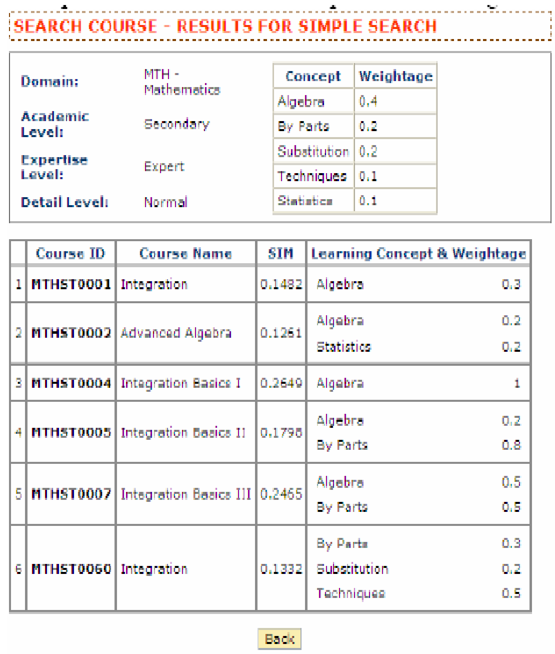


Figure 5: Search Form (Basic)

With the above information, the system will search through the database for courses within the Mathematics (MTH) domain, 'expert' expertise level and 'normal' detail level. The retrieved search results will then be ranked using the similarity index (sim) formula.

$$sim(di,q) = \frac{\vec{d_i} \bullet \vec{q}}{\left|\vec{d_i}\right| \times \left|\vec{q}\right|} = \frac{\sum_{i=1}^{t} w_{i-j} \times w_{i-q}}{\sqrt{\sum_{i=1}^{t} w^2_{i-j}} \times \sqrt{\sum_{i=1}^{t} w^2_{i-q}}} \qquad \text{eq. 1}$$

eq. 1 presents the similarity index (sim) formula which captures a scale invariant understanding of similarity. We use this cosine measure to represent the similarity between the query and the course documents where Document, $d_j = (w_{1j}, w_{2j}, \ldots\ldots, w_{tj})$ and Query, $q = (w_{1q}, w_{2q}, \ldots\ldots, w_{tq})$. This formula will consider all courses within the mathematics domain which teach at least one learning concept. An example of the search result is presented in Figure 6.


SEARCH COURSE - RESULTS FOR SIMPLE SEARCH

		Concept	Weightage
Domain:	MTH - Mathematics	Algebra	0.4
Academic Level:	Secondary	By Parts	0.2
Expertise Level:	Expert	Substitution	0.2
Detail Level:	Normal	Techniques	0.1
		Statistics	0.1

	Course ID	Course Name	SIM	Learning Concept & Weightage
1	MTHST0001	Integration	0.1482	Algebra 0.3
2	MTHST0002	Advanced Algebra	0.1261	Algebra 0.2 Statistics 0.2
3	MTHST0004	Integration Basics I	0.2649	Algebra 1
4	MTHST0005	Integration Basics II	0.1798	Algebra 0.2 By Parts 0.8
5	MTHST0007	Integration Basics III	0.2465	Algebra 0.5 By Parts 0.5
6	MTHST0060	Integration	0.1332	By Parts 0.3 Substitution 0.2 Techniques 0.5

Back

Figure 6: Search Result (Basic)

ADVANCED SEARCH

For an advanced search, besides the mandatory fields from a basic search, the learner can also specify the following fields: Cross Domain, Cross Expertise, Cross Details and Search Levels. These fields are used to enhance the search. They act upon the results that were retrieved by the basic search (fig. 7).

Advanced Search Options

1. (Optional) Cross Domain
2. (Optional) Cross Expertise
3. (Optional) Cross Details
4. (Mandatory) Search Levels

The advanced options allow the learner to specify whether the search should include courses in the same or different domain/details/expertise level. The search level option allows the learner to state the degree to extend the search. This is a mandatory field for concept mapping. It acts upon the results from the basic search and extends the search to include the retrieved course's external structure. Each group of external structure constitutes a level. E.g., a search level of 2 will mean that the search will extend from course → course's external structure (level 1) → level 1 courses' external structure (level 2) (fig. 8).

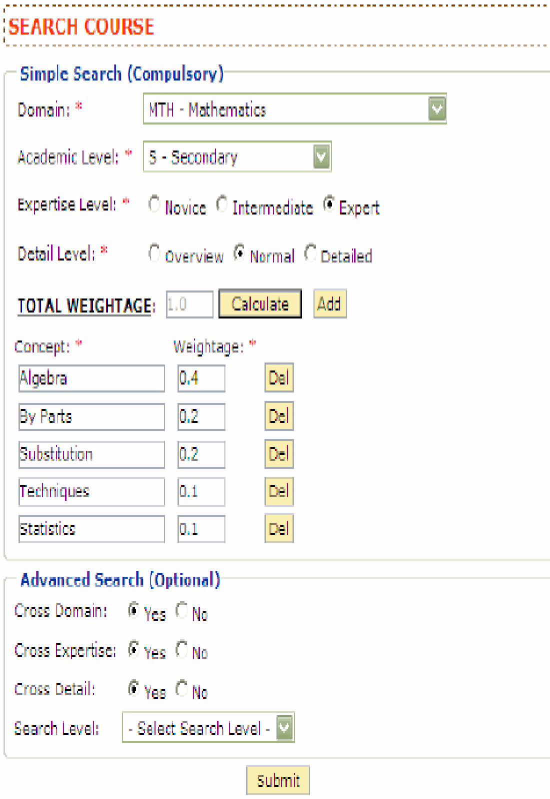
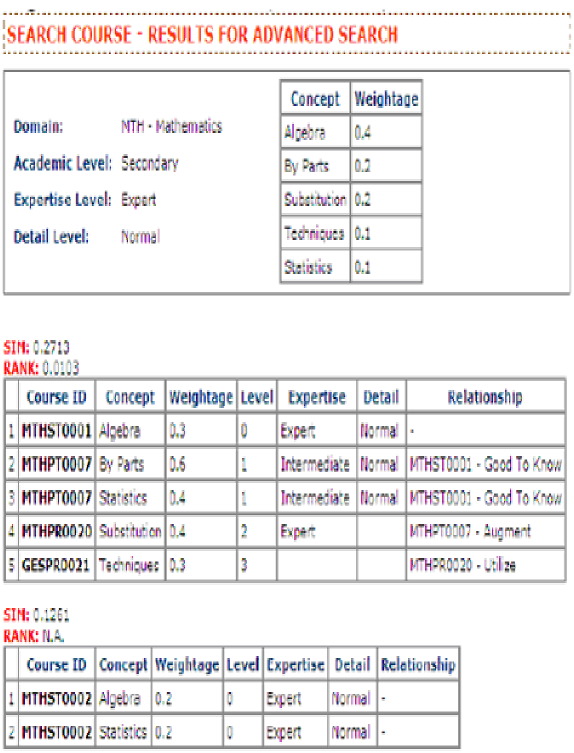


Figure 7: Search Form (Advanced)



SEARCH COURSE - RESULTS FOR ADVANCED SEARCH

Domain: MTH - Mathematics
Academic Level: Secondary
Expertise Level: Expert
Detail Level: Normal

Concept	Weightage
Algebra	0.4
By Parts	0.2
Substitution	0.2
Techniques	0.1
Statistics	0.1

SIM: 0.2713
RANK: 0.0103

	Course ID	Concept	Weightage	Level	Expertise	Detail	Relationship
1	MTHST0001	Algebra	0.3	0	Expert	Normal	-
2	MTHPT0007	By Parts	0.6	1	Intermediate	Normal	MTHST0001 - Good To Know
3	MTHPT0007	Statistics	0.4	1	Intermediate	Normal	MTHST0001 - Good To Know
4	MTHPR0020	Substitution	0.4	2	Expert		MTHPT0007 - Augment
5	GESPR0021	Techniques	0.3	3			MTHPR0020 - Utilize

SIM: 0.1261
RANK: N.A.

	Course ID	Concept	Weightage	Level	Expertise	Detail	Relationship
1	MTHST0002	Algebra	0.2	0	Expert	Normal	-
2	MTHST0002	Statistics	0.2	0	Expert	Normal	-

Figure 8: Search Result (Advanced)

4.4 PERSONALIZED COURSE OFFERING

The search result shows courses that impart the requested learning concepts. While our solution that recommends a combination of courses, is already a more complete learning solution than current learning solutions offering, this solution is still too generalized and does not take the learner's prior knowledge into consideration, i.e. every learner who has the same learning request will be presented with the same learning solution. Our system hence, takes learning one step further by streamlining assessment with personalized learning to recommend courses that start off from the learner's prior knowledge. Through our novel method of externalizing one's cognitive structure into a concept map format (C-Map), our system synthesized the courses from the C-Map and the search result (E-Map) to generate a personalized map (P-Map). P-Map is essentially a learning map of all the possible learning paths from the learner's current knowledge point to his targeted knowledge point. The learning concepts in the learning route are presented in a sequential manner and define the prior and essential learning concepts that must be mastered before certain targeted concepts can be learned Using course MTHST0001 in Figure 8 as an example, its CDL and E-Map is retrieved (Fig. 9). From the map, if a learner wishes to master the concept of algebra, he must first master the concept of Real Numbers and Equations. Using this E-Map, the system will then check the learner's C-Map for the competency of learning concept: Real Numbers and Equations. If these concepts are not present in the learner's C-Map – implying that these concepts have not been learned – then the course offering will commence from these 2 learning concepts before it extends to the concept of algebra.

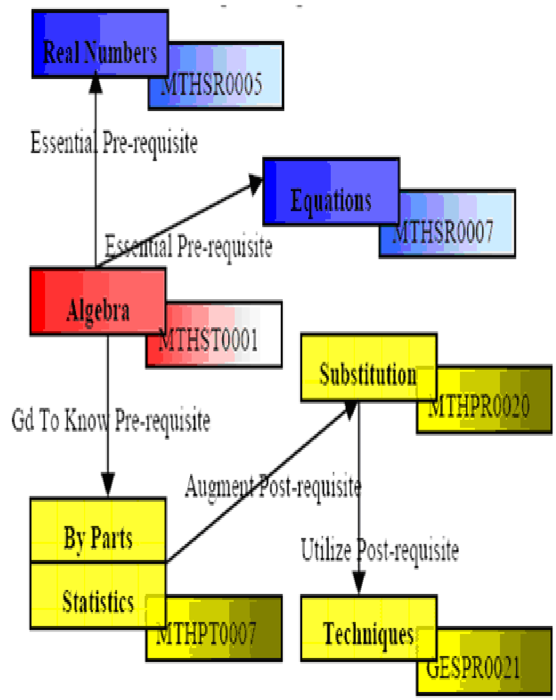


Figure 9: E-Map for Course MTHST001

5. CONCLUSION

E-learning has held the promise for personal learning in a time where knowledge is at a premium. However, this seems to have currently got lost in a scramble, as training providers try but fail in their quest to keep pace with the audience and the dynamics of the learning environment. In the end, in trying to embrace technology to provide interactive – meaning "read fanciful" – content to entice learners, the training providers are mislead into thinking that these fanciful contents do in fact entail e-learning. In this paper, we report a prototype system that streamlines the educational process into one seamless learning activity, integrating personalized assessment with learning. We advocate that such an approach truly utilizes existing technology for realizing cognitivism and constructivism concepts to enhance learning in the 21st century. Further research effort is needed, especially in field testing, to obtain real data and refine the system. There can be no substitute for this.

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