CONCEPT CLASSIFICATION FOR MATHEMATICAL e-CONTENT AUTOMATION FOR DIFFERENT e-LEARNER CHARACTERISTICS

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ABSTRACT

Portrayals also known as cognitive structures could quantitatively represent any problem centric subject e-content, so as to facilitate better comprehension for different types and levels of e-learners. Therefore portrayals may be explicitly represented in conceptual e-contents. This paper has considered David Merrill's four cognitive structures namely Activation, Demonstration, Application and Integration that are infused in an e-content of chosen mathematical subject content in an experimental study. They are symbolized in the form of ontological constructs of the chosen subject content (topic) and also in the form of action portrayal words (concept keywords) that represent the specific cognitive structure. It is proposed to tag these textual documents with the e-content objects, so that correct selection would be possible. The paper demonstrates clearly that the proposed approach will easily and correctly cater to different learner characteristics, as different types and levels of e-learners would like to use appropriate levels and kinds of e-contents of the same mathematical subject contents. The proposed ontology that is clubbed with appropriate portrayal keywords has been proved to identify the correct e-learning objects according to the learner characteristics. The proposed approach is based on literature support on concept mining using cognitive structures. The experimental results show a comparative study on different learner characteristics with respect to a chosen base learner character, so as to demonstrate the appropriateness of the e-content and the intensities of comprehension achieved by different types and levels of characteristics (e-learners). Concluding remarks drawn by the experiment would be of immense use to e-content developers and concept extractors.

Keywords: Concept mining, e-content representation, Cognitive portrayals, Learner characteristics

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INTRODUCTION

Keywords are generally used for document extractions mostly from the internet, while concept keywords may be used for identification of conceptual documents, such as mathematical subject e-contents. Issues will arise, if target documents contain graphics with or without text. Even in graphical documents, concept key words that are tagged with documents might be used for identification. How to achieve this is a major issue. Concept word or concept keyword is a word that represents a key concept used for comprehending subject content [3]. Three such types for text extractions have been spelt out namely, Ideal concept keywords, which have proven to improve program understanding by some objective measurements; Human-selected concept keywords, which a developer or reviewer believes are ideal concept keywords, even apt when graphics could be tagged with concept words; Machine-extracted concept keywords, which a method like tf/idf (Term Frequency Inverse Document Frequency) produces an approximation of ideal or human selected ones, based on mere keywords (non conceptual). Literature dealing with issues on identification of concepts from textual or other media documents is rare. Extraction of data from instructional textual documents so as to conceive its concept under exploratory learning environments had been reported [6]. However it is often difficult and time consuming, especially for novel applications such as exploratory learning environments of mathematical e-contents, for which there is still limited knowledge on what constitutes effective exploratory behavior. Yet, few existing approaches to this problem have been very knowledge intensive, relying on time-consuming, detailed analysis of the target system, instructional domain and learning processes. Since these approaches are so domain/application specific (such as 'Statistics, Probability and Random Processes') subjects of Mathematics, it is difficult to generalize the technique to other domains and applications. This paper therefore attempts to formulate a classification technique specifically on e-contents of mathematical subject, in terms of both subject content as well as learning pedagogical entities called Cognitive structures. The paper demonstrates with experimental results on a sample topic namely 'Data and Variables' of the subject 'Statistics' of mathematics that is instructed to different learner characteristics. The paper suggests tagging the documents (e-content objects) with two types of concept words, namely for subject content and for learning Cognitive structures. Concluding remarks drawn out of the experiment would be of immense value to e-content developers and concept extraction researchers.

E-CONTENT DEVELOPMENT OF MATHEMATICAL SUBJECT OBJECT

E-Learning in mathematics of technical institutions by students of engineering, say Computer Science and Engineering (CSE) or Electronics and Communication Engineering (ECE) requires multi disciplinary approach. This is because mathematics education is a discipline within other disciplines. In such situation, mathematics education as a discipline sits between mathematics on the one hand [2], and a range of other disciplines (such as psychology, human development, sociology, philosophy, epistemology, pedagogy, curriculum studies, policy studies and science) along with CSE or ECE, as these recipients need to comprehend the applications of it in their relevant discipline. Therefore underpinning research findings and concepts are needed from these disciplines to know "how to instruct mathematics better through e-content?". Mathematics e-Learning also draws its research methods from these and other disciplines, and the need to take stock of the plethora of approaches is an ongoing concern. Statistics, Probability and Random Processes are some of the subject areas of mathematics that are extensively taught in engineering disciplines, through the internet. Development of Self Instructional Material (SIM) for e-Learning, needed to respond to the following concerns that were particularly related to objectives for specific learner characteristics, course coverage, instructional standard to be achieved and media to be used [1].

- The objectives of any e-course needed to be stated prior hand, in terms of training outcome for specific learner characteristics.
- E-Course contents or syllabus must be divided into smaller units (objects) comprising of related topics.
- The learning experience and activities needed to be designed so as to help the learner achieve the designated result through specific media or channels of learning.

The best e-Learning materials would be, when: developed with a specific target audience in mind; highly integrated across sections; and included appropriate media components. It might be unlikely that a carbon copy of any course produced elsewhere in any other learning method could be adopted, particularly for specific learner characteristics. Bearing in mind on the above concerns the paper combines both subject concept key words as well as learning ability (Cognitive structures) key words for identifying e-contents.

Instructional Model for e-content development

Instructional design theories were goal-oriented and identified methods of instruction for specific situations. These methods had sets of components, which made them flexible and adaptable. Instructional design models had the ambition to provide a link between learning theories and the practice of building instructional systems, specifically for the e-mode. Some instructional design theories for e-Learning were: Cognitive Education, Multiple Approaches to understanding, Teaching and Learning for Understanding, Open Learning Environments, Constructivist Learning, Learning By Doing, Collaborative Problem Solving, Problem-Based Learning (PBL) and First Principles of Instruction (FPI) [4]. Restricted textual materials in slides are the one suggested by Carroll’s Minimalist theory, the theory which is most applicable to computers and online instruction according to [5]. The theory suggests that:

a. All learning activities should be meaningful and self-contained.
b. Activities should exploit the learner’s prior experience and knowledge.
c. Learners should be given realistic projects as quickly as possible
d. Instruction should permit self-directed reasoning and improvising.
e. Training materials and activities should provide for error recognition and use errors as learning opportunities.
f. There should be a close linkage between training and the actual system because “new users are always learning computer methods in the context of specific preexisting goals and expectations”.

This theory although specifies many explicit entities for online learning instructions, the Instructional sequencing is not overtly specified (unlike Merrill's FPI). Besides, according to this theory, slides or e-frames will have minimal texts and many times pure graphics or videos. Accordingly Merrill's model, the First Principles of Instruction (FPI) has been adopted for the experiment described in this paper. The chosen learning abilities in terms of FPI's Cognitive structures are three types: 'Activation' – Learner recalls her previously learnt material/concepts; 'Demonstrated Application' – Learner observes a demonstration by the e-system with a numerical example; 'Summation/Integration' – Learner is able to (ready to) apply her learned material to real life situation. The above definitions have been taken from FPI [4], with slight modifications, namely the 'Demonstration' and 'Application' of FPI have been joined together, as mathematics subjects are always instructed with numerical examples. Thus FPI is structured and small objects could explicitly prepared and reused for different learner characteristics.

Learner characteristics for learning 'Data and Variable'

The chosen topic for experiment is 'Data and Variable' of 'Statistics' that is included for various courses of a delimited University of South India (Table 1.0). The Table 1.0 presents the percentile values of the chosen subject content in relation to the volume of the subject content that is taught in the base course IBT (see Table 1.0). The table also presents the required learning abilities (Cognitive Structures of FPI) that are needed by different learner characteristics (of the same delimited University syllabus). These were arrived by us through a detailed curricular study.

Table 1.0 Percentages of Content and Cognitive Structures of Statistics' subject Topic: 'Data and Variable'

S.No	Branch code	Portions of Content and Cognitive Structures				
		In Content	In Cognitive Structures			
			Activation	Demonstrated Application	Integration	Total % of Base
1	IBT (Base)	100%	10%	80%	10%	100%
2	ECE	25%	5%	20%	-	25%
3	EIE/ICE	25%	5%	20%	-	25%
4	CHEM	25%	5%	20%	-	25%
5	IT	10%	10%	-	-	10%
6	BMI	10%	10%	-	-	10%
7	MBA	50%	10%	70%	20%	100%

Legend: IBT:

In Table 1.0, the subject content 'Data and Variable' that is considered for the course IBT is considered as the base with 100% instruction. The required Cognitive structures are also presented. For other courses, the requirements vary in both content as well as learning abilities. They are indicated in the same table. This clearly indicates that, while even the subject content could be the same for different courses, the required Cognitive structures might be different.

Therefore, the slides of the subject content in e-mode have to be differently chosen for different learners. To select appropriate slide, we have proposed to tag each such slide with two entities: i. the textual content with appropriate concept words of a particular Cognitive structure (for the experiment we have considered 'Activation' of FPI) of the slide and ii. The concept words for the appropriate Cognitive structure in the form of a compendium. Both are presented below (in single line spacing) that are designed for ECE learner characteristics for the experiment.

Tagged texts for 'ACTIVATION' of 'Data and Variables'

"Data and variables are mostly used in descriptive statistics. Descriptive statistics deal with qualitative aspects. An example of qualitative survey could be: a feedback with an answer "Working well" of a test result of an electronic control system. The other type is quantitative. Quantitative on the other hand measures numerical values. For example, the measured voltage value of a particular SMPS is 4.9 Volts. There are two types of quantitative data namely, discrete and continuous. Example of a discrete value is 9600 KHz. Data and variables are not only used in descriptive statistics, but also used in inferential statistics and in other areas. Descriptive statistics is a branch of statistics that are concerned with describing sets of measurements of both samples and population. The term 'Measurements' must be known first. Measurements are defined as technique of measuring data for categorizing certain values of them into some types of data that are likely to be encountered in real life. For example, the calibrated values of several electronic measuring devices. Data in statistics is also known as collection of facts.

A variable on the other hand is a characteristic that changes or varies over time and/or for different individuals or objects under consideration. For example, the radio waves received from a satellite from morning 8 am till evening 8 pm at every one hour.

COMPENDIUM

Compendium defines data and variables for ECE statistics. It tells what data is and what is variable used in statistics with examples in ECE. It differentiates between discrete and continuous data. It introduces what is descriptive statistics. It recollects measurements."

We suggest tagging each slide with these two textual entities, for any media of e-content, say text or graphics or even video. For the experiments, we have indicated the concept key words in the slides.

EXPERIMENTAL STUDY

Figures 1.0 shows the presence of ontology concept words for the chosen topic. The frames (Figure 1.0) also show that the ontology does not follow hierarchy unlike mere key word ontology. The frame also includes concept words of learning abilities (restricted to 'Activation' of FPI for the experiment).

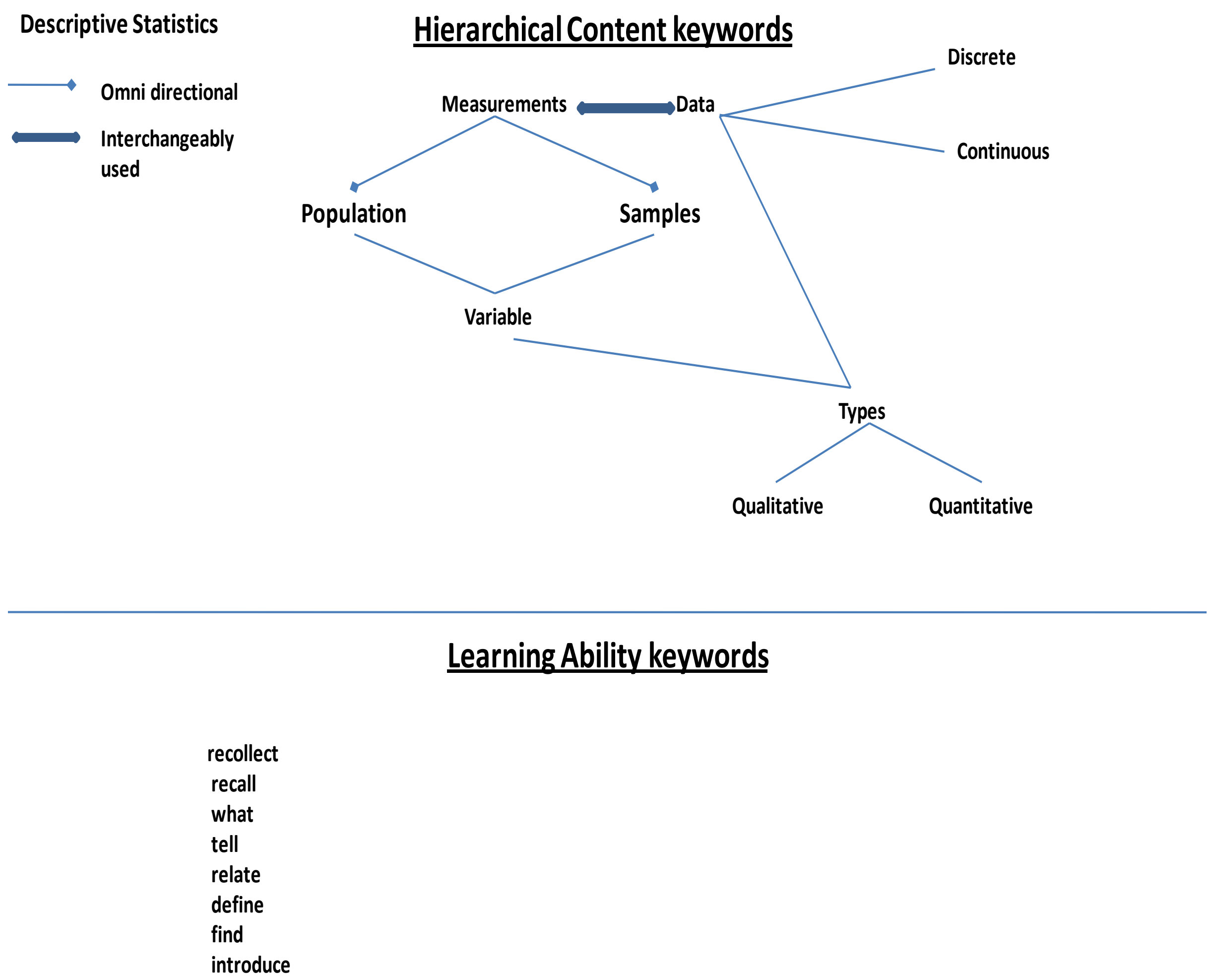
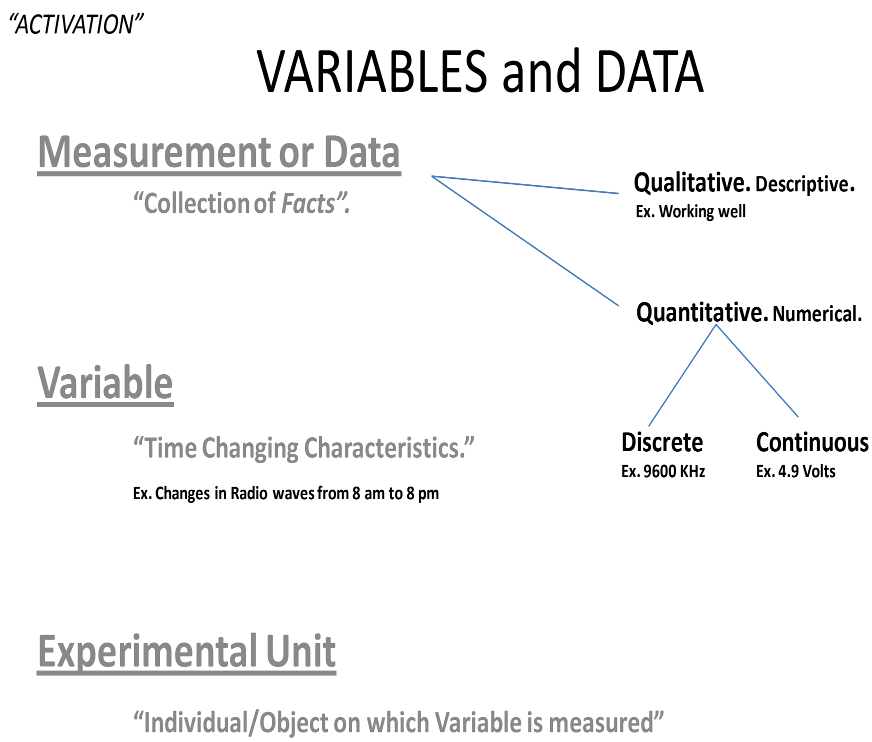
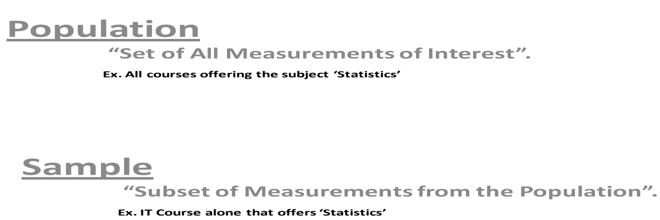


Figure 1.0 Non-Hierarchical Ontology for 'Activation' Concept words

Subject Concept Ontology and Concept word Tagging



Frame1. Slide for 'Activation' on 'Variables and Data'



Frame2. Second slide on 'Variables and Data'

RESULTS AND DISCUSSIONS

The chosen topic, even though is same for all the courses, the learner characteristics are different from course to course (see Table 1.0). The e-content for the experiment is chosen for the ECE course and therefore the examples included in the e-content have included such numerical examples. When the instructions are experimented with two sets of students namely, ECE (60 students) and IBT (60 students), the ANOVA test conducted and analyzed through SPSS 17.0 (results are not presented and is beyond the scope of this paper), clearly indicated that the students of ECE have grasped the 'Activation' part more clearly, while the IBT students have not up to the expected mark in 'Activation' learning ability. The experiment has also clearly indicated that the concept key words for both the subject content as well as learning abilities when tagged with e-content objects would chose appropriate e-contents for particular learner characteristics.

CONCLUSIONS

It is clearly demonstrated that Concept words for both subject content as well as learning abilities need to be tagged with every mathematical e-content object so as to correctly select appropriate e-content for specific learner characteristics. E-Learning of mathematics will be effective when objects are designed separately for different learner characteristics, even though the mathematics subject content could be same or similar.

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