

# Dynamic User Interface Based on Cognitive Approach in Web Based Learning

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## Abstract

With bandwidth increasing at a constant pace, technology in education has become an important part for delivery of educational content to students. Online learning in various forms is gaining popularity but lacks the adaptability required to hold the learners attention due to its rigid structure. Though animation and powerful graphics enhance the learning content, delivery of content according to learners need is yet to become a reality. It is not possible to build a learning system that can satisfy every learner as some people respond best when they see basic facts on a clean page, others when they have a lot of charts and graphs at their fingertips. To overcome these shortcomings the content delivery itself can be made dynamic based on the learner's need. In this paper we propose a novel method to identify a user's need based on the cognitive behavior of the user. Based on the response of the user, a decision tree induction algorithm is used to predict the requirements of future users.

**Keywords:** *User interface design, Cognitive approach, online learning, and decision tree induction.*

## 1. Introduction

Web based learning encompasses all tools that make use of the internet for delivery of learning content. The learning content can be in the form of tutorials, online discussion group or virtual platform for hands on training[1]. However the distinction on the types is blurred and overlaps each other. Web based learning tries to eliminate face to face lectures and is enhanced using multimedia followed by self assessment tools[2]. Online discussion

groups involve a group of students facilitated by a teacher online who may involve in didactic teaching [3].

Web learning represents the evolution of computer assisted instruction for the delivery of content over the internet. Web based learning include hyperlink functions that permit cross referencing to other resources and searching capabilities which are crucial for the principles of constructivism based learning[4] theory which emphasizes that learners create their own knowledge base over a period of time. However the disadvantages faced in computer assisted instruction translates to web based learning and hence significant improvements may not be obtained if the content and user interface is not proper. Advantages of web based learning include the overcoming of physical distance which is a cardinal feature separating web based learning form other computer assisted teaching methods[5]. Web based learning facilitates the teaching of students scattered globally which also permits the possibility of economies of scale. The major disadvantages of web based learning include social isolation, de individualized instruction, poor instructional design and technical problems [6].

Cognitive theory of learning suggest that learning is based on mental processes [7,8,9] while behavioral learning method suggests that learning results from pleasant or unpleasant experiences in life. Since epistemological processes are related to cognitive theory, the learning process comes out of experience, perception, memory and overtly verbal thinking[10,11]. The list of

theories associated with cognitive theory is very expansive and contemporary theory include information processing theory, schema theory and situated cognition theory[12]. Information processing deals with the storage and retrieval of knowledge in the mind. Schema theory[13] is based on the way a person interprets a subject based on categorical rules. In schema theory information is processed according to as how these fit into the categorical rules or schemes[14].

In this paper we propose a novel method to provide a dynamic learning system which adapts according to the cognitive behavior of the user. A cognitive based feedback questionnaire is used to capture the likes and dislikes of the user which is used to train the decision tree algorithm. Once trained the algorithm can automatically predict the requirements of a new student based on his cognitive behavior and past experience of other students.

## 2. USER INTERFACE DESIGN

### UI DESIGN PRINCIPLES

Constantine and Lockwood describe a collection of principles for improving the quality of user interface design. These principles are

#### 2.1 The Structure Principle

The design should organize the user interface purposefully, in meaningful and useful ways based on clear, consistent models that are apparent and recognizable to users, putting related things, differentiating dissimilar things and making similar things, differentiating dissimilar things resemble one another.

**The Simplicity Principle:** The design should make simple, common tasks simple to do, communicating clearly and simply in the user's own language, and providing good shortcuts that are meaningfully related to longer procedures.

**The Visibility Principle:** The design should keep all needed options and materials for a given task visible without distracting the users with extraneous or redundant information. Good designs don't overwhelm users with too many alternatives or confuse them with unwanted information.

**The Feedback Principle:** The design should update users in changes of both state and condition that are relevant and of interest to the user.

**The Tolerance Principle:** The design should be flexible and tolerant so that the user is not affected by the mistakes unknowingly done and hence should be capable of undoing and redoing.

**The Reuse Principle:** The design should reuse components and behaviors to establish consistency.

### 3. EXPERIMENTAL SETUP:

The cognitive behaviors of 82 students studying in undergraduate and postgraduate courses were captured using questionnaires. They were initially subjected to go through a known subject and an unknown subject in a popular online learning website. Typical questions were in the areas of

- Learn ability
- Indication about meaningfulness of error messages
- Preference to read text rather than to listen to a lecture
- Interest level in deciphering graphs, charts, and diagrams
- Visualization of content read as a mental picture
- Depth of study in the subject area.

Class labels indicating the type of online learning system preferred is assigned to all the 82 students obtained from the questionnaire. The various cognitive attributes are used as the training input for the J48 decision tree induction algorithm and the Naïve Bayesian algorithm. Decision tree structures have been proposed extensively to organize classification schemes. During classification decision trees visualize what steps need to be taken to arrive at a classification. Decision tree begins with a root node followed by intermediate node and terminates with leaf which relates to the class label. Each node in the tree evaluates an attribute in the data and determines which the intermediate node to follow. The decision is taken is based on comparing the attribute value with a constant computed using various schemes. Decision tree induction algorithms work recursively with the selection one attribute as the root node with the root node effectively splitting the data. In order to create the smallest tree, the technique for splitting the root node must be efficient. The best split is the one that provides the best information gain. In this paper we use the j48 decision tree induction classification method.

In this work the J48 algorithm is selected which gives several options related to tree pruning for reducing computing time. Pruning has the advantage of interpreting the results easily. More importantly, pruning can be used to avoid over fitting. The basic algorithm described above recursively classifies until each leaf is pure, which means that the attributes have been assigned a class label accurately. This process ensures maximum accuracy on the

training data however it may create excessive rules which are not required. When tested on new data, the rules may not be as effective as in training data. Pruning reduces the accuracy of a model on training data, but improves the overall performance. This is because pruning employs various means to relax the specificity of the decision tree, and assumes that the performance will improve on test data.

Naive Bayes is one of the most efficient and effective inductive learning algorithms for machine learning and data mining. Its competitive performance in classification is surprising, because the conditional independence assumption, on which it is based, is rarely true in real world applications. A naive Bayes classifier is a simple probabilistic classifier based on applying Bayes' theorem with strong (naive) independence assumptions. A more descriptive term for the underlying probability model would be independent feature model. In mathematics, a classifier is a mapping from a discrete or continuous feature space  $X$  to a discrete set of labels  $Y$ .

Given a set of variables,  $X = \{x_1, x_2, \dots, x_n\}$ , constructing the posterior probability from a set of possible outcomes  $Y = \{y_1, y_2, \dots, y_n\}$ . Using Bayes rule  

$$P(Y_j | x_1, x_2, \dots, x_n) = p(x_1, x_2, \dots, x_n | C_j) p(C_j)$$
  
 Since Naive Bayes assumes that the conditional probabilities of the independent variables are independent we can decompose to

$$p(X | Y_j) = \prod_{k=1}^n p(x_k | Y_j)$$

The posterior can be rewritten as

$$p(Y_j | X) = p(Y_j) \prod_{k=1}^n p(x_k | C_j)$$

Using Bayes' rule above, we label a new case  $X$  with a class level  $Y_j$  that achieves the highest posterior probability.

Some of the sample questions from the questionnaire include

1. I prefer content that is challenging so I can learn new things.
2. Compared with other websites this website is better in terms of content.
3. I am so nervous during the online test that I cannot remember facts I have learned
4. When I study for a test, I try to put together the information from the course content

5. When I do homework, I try to remember what I learnt in the website so I can answer the questions correctly
6. Even when study materials are dull and uninteresting, I keep working until I finish
7. When I study for a test I practice saying the important facts over and over to myself
8. Before I begin studying I think about the things I will need to do to learn.

The distribution of answers for some of the queries is given in figure I. Figure II illustrates the preference of the delivery content. This research focuses on the dependency of the preference of delivery method over the cognitive behavior of the person.

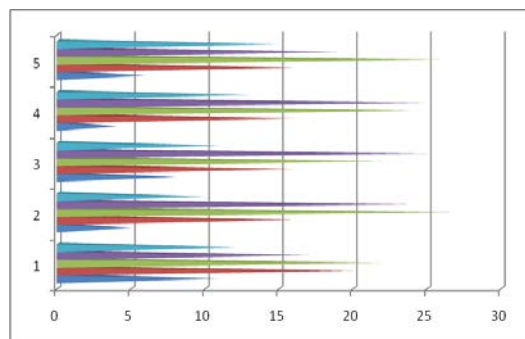


Figure I: Frequency of answers for some of the questions.

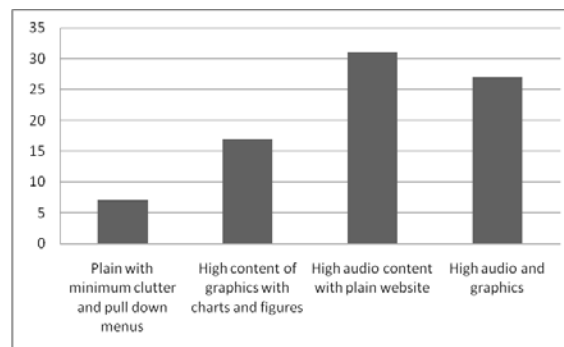


Figure II: Preferred delivery methodology

The classification accuracy of the proposed method in identifying his requirements based on the cognitive input is shown in figure III. The high classification accuracy is due to the 30 questions asked relative to the cognition theory and the relationship between the learner's preferences for the website.

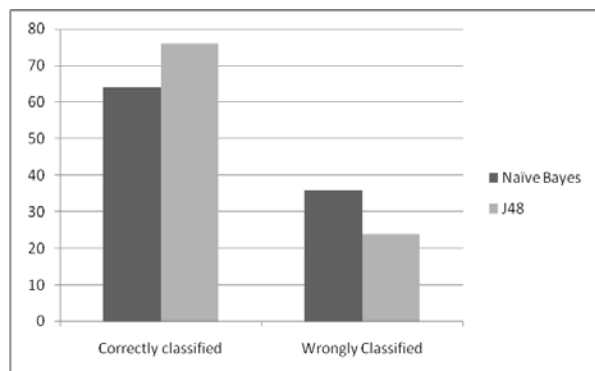


Figure III : Prediction accuracy of J48 based decision tree algorithm and Naïve Bayes for the proposed cognitive based adaptive learning system.

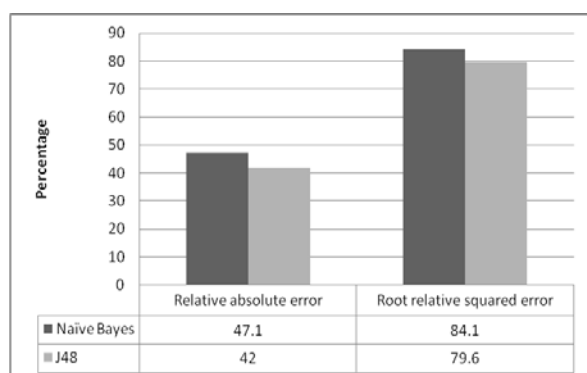


Figure IV : The Relative absolute error and the root relative squared error.

#### 4. CONCLUSION:

In this paper we capture the cognitive behavior of the user through questionnaire. The preferred layout of the web learning system is also captured in the questionnaire which is used as the class label for the decision tree algorithm based on J48 and the Naïve Bayes classifier. J48 is able to predict accurately the requirement of the user at an accuracy of 76%. With recommender systems becoming increasingly popular the proposed method proves that cognition can be used as a base to provide better user interface to every specific user.

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