



Development of Web based Learning System for Pre-K to Middle School Math Students: Optimization Strategies for Online Learning

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Abstract: This research paper has been designed to develop an online tutoring system for pre-K to middle school Math students. The research methodology applied in this study has used both qualitative and quantitative research methods in terms of external and internal Web or software metrics to obtain the usable parameters to design an effective tutoring system to learn Math. Today online hypermedia applications are increasingly becoming more feature rich, important and also the most popular means for communication among school students for e-learning. This paper is divided into four parts: part 'I' presents the introduction of Kumon based after school education; part 'II' describes the research proposal to identify measures, model, and methodology to develop the Web-based online learning system for Pre-K to middle school math students; part 'III' elaborates the role of using static analysis, dynamic, and comparative analysis that can be applied to check the characteristics and authenticity of data obtained for each student separately; and finally part 'IV' investigates the behaviour of online tutoring system to find the failure points and to calculate reliability aspects using Web page trace algorithms and Web page replacement policies. In this paper, an attempt has been made to systematically explain the state of the art and their practices to design, analyze, and test the functionality of online learning systems for pre-K to middle school Math students.

Keywords: Behaviour analysis, effort estimation, online tutoring system, Kumon's Mathematics, qualitative and quantitative analysis, Web page replacement policies and algorithms.

I. Introduction

The Today's Websites are much more than simple graphically oriented hypertext or hypermedia applications and are becoming key entry points for customers and clients of an organization. Web-based hypermedia applications have great potential in areas such as education, and training to mention but a few. This paper is designed to develop a Web based online learning system for pre-K to middle school Math students that would be similar to Kumon style after school education. Kumon has shown to be very effective supplement to normal school activities. On the other side, reliable and precise effort related to students' work is critical for such project selection, planning and control. Over the past thirty years, various estimation models have been developed to perform estimation tasks for online applications, and this has led to a market offering of estimation tools. The construction of an estimation model usually requires a set of completed projects from which an arithmetic model is derived and which is used subsequently as the basis for the estimation of future projects. Hence, there is a need for an estimation model for the development effort related to Kumon based after school education. By calculating the efforts, the performance of each student will be judged individually (viz. accuracy, speed, difficulties etc.). In this research paper, it is tried to point out the need for predictive metrics to measure development effort for such Web-based designs. Furthermore, a new set of database and their related tables can be made on the basis of a complete hypothetical study. The hypothetical study could also be conducted by providing the dataset of Web documents or Websites. As a result, an empirical research can be carried out to provide effort assessment for Kumon based online applications. For this, many findings related to student nature and interest can also be analyzed from the qualitative and quantitative parameters. The final analyses would definitely suggest several areas (including reliability, usability, complexity, cost, time requirements and type of nature of Web design) where students have nothing to pay for their tutorials and leanings.

Unfortunately, many families are not able to pay the associated fees for such supplemental instruction available through Kumon after school education, which is a costlier affair. Hence, there is a need of cost effective and

reliable medium just like Kumon that would be helpful for pre-K to middle school students Math. Therefore, there is a need of online tutoring system that would have the worksheet driven nature to access the educational material through the Web. The main difference of this type from normal database of worksheets is that worksheet will be developed for each student individually. It will progress at appropriate speeds to meet each student individually. It will develop worksheets to focus on areas of weakness. Furthermore, students will have access to online video demonstrations of every topic. The goal is to substantially impact Math proficiency when it really matters early in their education.

II. Kumon Mathematics

The Kumon is a mathematics education method, which was founded in 1958 by educator Toru Kumon. Mr. Toru Kumon judged the children's capabilities in mathematics that could eventually be developed with a self-study and independent learning method. The Kumon method supports several ways of learning, which include speed, accuracy and mastery of material before a student is able to move on to the next lesson. As of 2009, over 4 million students were studying under the Kumon Method at more than 26,000 Kumon Centers in 46 countries [1].

A. Kumon's Mathematics Curriculum

Basically, Kumon is a math and reading enrichment program. Students do not need to work together as a class, but they progress through the different level of mathematics curriculum at their own speed, moving on to the next advanced level when they have achieved proficiency of the previous level. Proficiency is defined as speed (using a standard completion time) and accuracy. The mathematics curriculum of Kumon consists of different levels as defined below [2]: -

- (i) Level 7A: Counting to 10.
- (ii) Level 6A: Counting to 30.
- (iii) Level 5A: Line drawing and number puzzles to 50.
- (iv) Level 4A: Reciting and writing numbers up to 220.
- (v) Level 3A: Adding with numbers up to 5.
- (vi) Level 2A: Adding with numbers up to 10, and subtracting with numbers up to 9.
- (vii) Level A: Horizontal addition and subtraction of larger numbers.
- (viii) Level B: Vertical addition and subtraction.
- (ix) Level C: Multiplication and division.
- (x) Level D: Long multiplication, long division, and introduction to fractions.
- (xi) Level E: Fractions.
- (xii) Level F: Four operations of fractions and decimals.
- (xiii) Level G: Positive/negative numbers, and introduction to algebra.
- (xiv) Level H: Linear/simultaneous equations, inequalities, functions, and graphs high school level math.
- (xv) Level I: Factorization, square roots, quadratic equations, and Pythagorean theorem.
- (xvi) Level J: Advanced algebra.
- (xvii) Level K: Functions: Quadratic, fractional, irrational, and exponential.
- (xviii) Level L: Logarithms, basic limits, derivatives, integrals, and its applications
- (xix) Level M: Trigonometry, straight lines, equation of circles.
- (xx) Level N: Loci, limits of functions, and sequences, differentiation.
- (xxi) Level O: Advanced differentiation, integration, applications of calculus, and differential equations.
- (xxii) Level X is an elective level; also, there are no tests available yet on this level.
 - o Level XT—Triangles: Sine, cosine theorems, and application of trigonometry in area.
 - o Level XV—Vectors: Vectors, inner products, equations of lines, planes, and figures in 3-space.
 - o Level XM—Linear algebra: Matrices, determinant, mapping, and linear transformation.
 - o Level XP—Probability: Permutations, combinations, probability, independent trials, and expected value.
 - o Level XS—Statistics: Binomial and normal distributions, probability density functions, confidence intervals, and hypothesis testing.

In addition, the Kumon language program varies regionally from one nation to other. The math program for most countries goes up to Level O and Level X. However, in Japan, the math program is available up to Level V.

III. Research Proposal

Today, when computers play a primary role in almost every area of our life. The increased importance of Web-based online applications also place more requirements on it. Thus, it is necessary to have precise, predictable, and repeatable control over the Web development process. On the other side, the development of Web-based online learning system for Pre-K to middle school math students is still a very challenging task for the coming future. By implementing such system, the performance of each student will be judged individually (viz. accuracy, speed, difficulties etc.). Web designers recognize the importance of realistic estimates of effort to the

successful management of online Web projects. Estimates are necessary throughout the whole development life cycle. Most estimates prediction models to date concentrate on functional measures of size, although length and complexity are also essential aspects of size in order to analyze the overall effect of parametric influence (including quantitative parameters such as size, number of errors, and qualitative parameters such as complexity, speed, required reliability, and tool usage and user capability). Therefore, an overall case study evaluation is required to predict the size metrics, characterizing length, complexity and functionality for online tutoring Web-based design system. A set of metrics is to be identified for estimation predication. Hence, the researcher intends to carry out the research in the following areas: -

- (a) Identification of measures that can be used to develop the Web-based Online tutoring system for Pre-K to middle school math students by constructing the User Behavior Model Graphs (UBMGs) to capture the reliability of Web-based applications via Web server log files as prime attributes.
- (b) Identification of a model that can be used to predict the efforts to complete the online datasheet of different levels of mathematics.
- (c) Identification of a model that can be used to predict the reliable effort estimations required using above –said measures.
- (d) Identification of a methodology that can help the Webmasters in controlling the efforts for online tutoring systems especially for Pre-K to middle school math students.

The research methodology will include data analysis, exploratory case study using questionnaires, experimentation and observation using a hypothetical Web site taxonomy.

IV. Qualitative & Quantitative Analysis

Despite its major role in Information and Communication Technology (ICT), the World Wide Web (WWW) remains uncontrolled. Today, any individual or organization can create their own Website with any number of documents and hyperlinks. This unprecedented growth of Web results in many challenges in terms of its expansion and their index value. However, the assessment of Websites by merely counting “hits” on a page is not an accurate measure of quality or success of a Website. But, it is always better to evaluate the behavior of visitors i.e. who are the visitors and how they are using the Websites. To do so, the data can be collected from monitoring log files, which can help to identify most frequently accessed pages and what are the peak usage times and days [3, 4, 5]. The following three research methodologies would be applied to check the characteristics and authenticity of data obtained for each student separately: -

- (i) Static analysis: It involves the analysis of a large number of Websites at a given time and allows the comparison of individual criteria (e.g., means, variances, or other statistical parameters).
- (ii) Dynamic analysis: When a defined set of Websites can be documented and analyzed over a longer period of time, i.e. a series of static analyses are conducted on the same sample. In the dynamic analysis the trends, variations, turning points, and marginal changes are monitored for the Websites.
- (iii) Comparative analysis: The comparative analysis is done in the case of real world organizations to analysis their own Websites with their competitors. It provides decision makers with reliable data about relevant differences and performance of their own Websites. Especially, this third category provides organizations with an important source of information for maximizing their customer delivered value and it can be incorporated into their own Websites. The comparative analysis is done with the help of various statistical tests (e.g., t-test, One-Way ANOVA, and Multiple regression). However, the quantitative parameters or indicators have been grouped into six major metrics to finally draw the conclusions and results.

As mentioned previously, one of the driving forces behind this study was to research new generic ideas for methods, practices, and processes that could be implemented to improve the Website design and finally to implement online education learning system for Pre-K to middle school math students. To carry out the qualitative and quantitative analysis, the following objectives are laid down: (i) Identification of qualitative parameters, (ii) Identification of quantitative parameters, (iii) Assessment of qualitative and quantitative parameters, (iv) Assessment of descriptive statistics in term of their mean (arithmetic), median, standard deviation, coefficient of variation, skewness using Kurtosis test, minimum and maximum range, and total number of observations, (v) Measurement of inferential statistics with their standard error, p-value, t-test, and f-statistics, (vi) implementation of correlation and regression using analysis of variance, multiple regression, and (vii) To draw the statistical graphs wherever necessary. Therefore, the subsequent objectives can be obtained, which can be used for any of the following conditions: (a) Knowledge: It explains the basic terminology and state fundamental facts about Web metrics and their process models, (b) Comprehension: It can define the metrics and their models, which can be used in the module, (c) Application: It is used to calculate the values of the Web metrics discussed for specific examples of Web-based software projects, products, and processes. (For example, compute Web objects and cost of development process for a specified project), (d) Analysis: It identifies the essential elements of a given Web metric or model by describing the interrelationships among its various elements in which its use is appropriate, (e) Synthesis: It is used to develop a plan for a Web metrics program for a Web-based software development organization, using well-defined Web centric metrics, and (f) Evaluation: It evaluates an objectives of Web metrics program by analyzing the Web-based metrics and models. Finally, the

student's behaviour and their performance in terms of log files can also be analyzed from the server log files [6, 7, 8, 9].

V. Behaviour Analysis of Online Tutoring System

The results obtained from the proposed design objectives can be used to find the failure points in Web-based systems and to calculate reliability aspects of the online tutoring system. UBMG can be represented in form of a graph or a matrix notation. The UBMG is a replicated view of Customer Behavior Model Graphs as discussed by Menace *et al.* [11]. In the graph view, nodes represent the pages, and arcs represent the transition from one node to another. The access logs store information regarding the timestamp, page accessed client-id, referrer-id, HTTP return code etc. for determining session information. A sample format of IIS log file is shown in figure 1.1.

```
#Fields: date time c-ip s-port cs-uri-stem cs-uri-query
sc-status time-taken cs (User-Agent) cs (Referrer)
```

Figure 1.1 format of IIS server log file.

The referrer-id and the client-id fields are considered as the basis to perform a depth first search on the access logs. Finally, by accessing all the entries from the Web server log files, one can apply Web page trace algorithms to judge the behaviour of each student datasheet separately [6,7, 8, 9].

A. Web Page Trace Algorithms

Consider a Web page trace $W(n)=r(1)*r(2)*\dots*r(n)$ consisting of n Web page numbers (WPNs) requested in discrete time from 1 to n , where $r(t)$ is the WPN requested at time t , and Web page trace is a sequence of Web page numbers. Therefore, two references distances are defined between the repeated occurrences of the same page in $W(n)$. The forward distance ' $f_t(x)$ ' for page ' x ' is the number of time slots required from time ' t ' to the first repeated reference of Web page ' x ' in the future, and it is given by: -

$$f_t(x) = \begin{cases} k, & \text{if } k \text{ is the smallest integer such that } r(t+k)=r(t)=x \text{ in } W(n) \\ \infty, & \text{if } x \text{ does not reappear in } W(n) \text{ beyond time } t \end{cases}$$

Similarly, a backward distance $b_t(x)$ is defined as the number of time slots from time ' t ' to the most recent reference of Web page ' x ' in the past, and it is represented by: -

$$f_t(x) = \begin{cases} k, & \text{if } k \text{ is the smallest integer such that } r(t-k)=r(t)=x \text{ in } W(n) \\ \infty, & \text{if } x \text{ never appeared in } W(n) \text{ in the past} \end{cases}$$

Let $R(t)$ be the resident set of all Web pages residing in Web server under the indexed Web page at time ' t '.

B. Web Page Replacement Policies

Basically, the page replacement policies are used in the operating systems as discussed by Hwang [10]. The same page replacement policies are used to trace out the behaviour of Web pages and hence those policies are renamed as Web page replacement policies. The following Web page replacement policies are used in a Web server system for a Web Frame Repetition (WFR), which results in Web page faults at time ' t '.

- Least recently used (LRU): This policy replaces the Web page in $R(t)$ which has the longest backward distance or it will replace the Web page that has not been recently used for the longest period of time.
- Optimal (OPT) algorithm: This policy replaces the Web page in $R(t)$ with the longest forward distance or replaces the Web page that will not be used for the longest period of time.
- First-in-first-out (FIFO): This policy replaces the Web page in $R(t)$ which has been in memory for the longest time.
- Least frequently used (LFU): This policy replaces the Web page in $R(t)$ which has been least referenced in the past or it replaces the page that has the smallest count.
- Most frequently used (MFU): This policy replaces the Web page in $R(t)$ which has been most referenced in the past.

VI. Justifications and Validations

On the basis of above mentioned Web-based designs and projected measurements techniques, the features and functionality of the application to be developed may be obtained to propose efficient Web-based measurements for Pre-K to middle school math students. This will be achieved using surveys (based upon hypothetical and Web-based analysis) and a case study. These proposed Web-based measurements techniques would be organized into categories and ranked. Results may be indicated by the common size metrics used for Web cost estimation. Therefore to analyze the behaviour and interest of for each student separately, Web servers log files, reliability, compatibility, usability, maintainability, complexity, cost, configuration, time requirements, Types of interfaces and type of nature of each datasheet may also be examined and considered. Finally, we will validate this study on the basis of Web-based measurements by taking the features and functionality of the application to be developed

for effort predictions in order to propose efficient Web-based online learning tutoring system. The task size and consequences of estimation errors will be predicted. However, the final results would suggest the various effects apply to estimate Web-based online tutoring systems, thus would be an invincible task for the upcoming future.

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