

A Quiz Generator Extension inside CMS for Mathematics Learning

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Abstract: *Addressing diagnostic assessments in e-learning projects is an important issue. Diagnostic assessment allows educators to assess student skills and progress. It provides diagnosis of students' strengths and weaknesses. We decided to implement an intelligent diagnostic assessment tool for middle school mathematics using Bayesian Networks, since mathematics learning requires an extreme control of the learning process for a better outcome. In fact, the assessment tool is included in a quiz generator that we implemented, a tool that helps for automatic generation of quizzes. The quizzes generated by this tool infer the level of each mathematical skill or ability; therefore the student can follow a learning strategy that is suitable to him/her in order to reinforce his or her weak skills or abilities.*

Since quizzes are brief assessments used to measure certain knowledge addressed in lecture materials, we decided to combine lecture materials and quizzes in a single software (CMS or Content management System). The integration of the quiz generator in a CMS will not only allow students to easily refer to class material while reviewing for a quiz but also, the CMS will serve as common platform for other mathematical tools that we might integrate in the future. The implementation of such features will make our software more consistent. The present document describes how we implemented diagnostic assessment tool within a CMS using web programming techniques and Mathematica software.

1 Introduction

This document describes a quiz generator that allows diagnostic assessment for middle school mathematics. It is embedded in Content Management System in order to associate generated quizzes with their matching lecture materials. It makes use of a mathematical software (Mathematica)^[1] for automated quiz correction and mathematical expression rendering. The CMS serves as a storage tool for mathematics content. Students can take generated quizzes and receive feedback afterwards. Each quiz is generated based on a Bayesian network. Formally, Bayesian networks are directed acyclic graphs whose nodes represent variables, and whose arcs encode conditional independencies between the variables^{[2][3]}. In other words, Bayesian networks are probabilistic graphical models that represent a set of variables and their probabilistic independencies. Furthermore, Bayesian networks describe the connection between questions in the quiz and the concepts required to answer each question. The results stored after the students take a quiz are used to update the Bayesian network with new probabilities. Those probabilities can further be used to predict actions taken by the student.

According to Mislevy and Gitomer, probability-based reasoning has emerged as a viable approach to structuring and managing knowledge in the presence of uncertainty.^[4]

Modeling Students models using Bayesian networks is our first step in diagnostic assessment. Educators can then use the quiz generator to create a quiz and assign reading materials to it. The quiz generator is connected to Mathematica in order to randomize questions and answers each time students take the quiz. After taking the quiz, the Bayesian network is updated with new probabilities that can infer student mastery level in each concept involved in the quiz.

2 Implementation of Quiz Generator on top of JOOMLA! Platform

2.1 Joomla as an educational tool

Joomla^[5] is a general-purpose Content Management System. However, its high efficiency and good design can extend it to be an effective educational. It is evident that it can easily store and organize educational content but since it is flexible (ability to add components to it) One can easily think of the possibility of adding educational applications whose functionalities are not included in a simple CMS (e.g classroom portfolios, quiz management etc..).

2.1.1 Facts about Joomla

Here are some interesting facts about Joomla!

- Over 60,000 registered users on the Official Joomla! community site forum and more on the many international community sites.
- Over 1168 Projects built on the Joomla! Platform.
- Over 890 Third party extensions for Joomla! registered on the Extension site (extensions.joomla.org)
- Alexa report [October 2006]: Joomla.org at #492 of top 500 busiest websites in the world.
- Community forums, over half a million posts, and 60 000 activated users. Growing at over 1200 posts per day and 150 new participants each day.

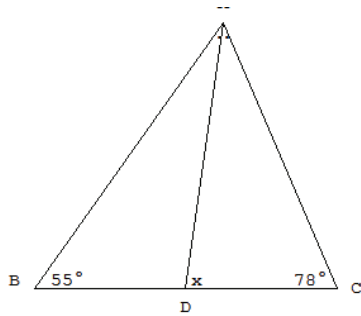
2.2 Mathematica

We used Mathematica and webMathematica to automate quiz generation. A sample code is shown in Figure 1. webMathematica allows a web browser to act as a front end to a remote Mathematica server. It is designed to allow a user written application to be remotely accessed via a browser on any platform. It may not be used to give full access to Mathematica. webMathematica provides a collection of tools that allow Mathematica commands to be placed inside HTML pages; each time the page is requested from the server, these commands are processed by a Mathematica session.

The values in the Sample quiz shown in figure 2 change every time the user refresh the page.

```
Display[fname, p, "GIF"];
Print[statement];
ans = Solve[x +  $\frac{180 - (r1 + r2)}{2}$  + 72 == 180, x] [[1, 1, 2]];
choices = genChoice[ans, 2];
printChoice[choices];
{ans, choices}
```

Figure 1. Quiz Generator code with Mathematica



Find the angle x .

- (1) $\frac{169}{2}$
- (2) $\frac{173}{2}$
- (3) $\frac{177}{2}$

Figure 2. A Sample Quiz

2.3 Implementation

The idea of implementing a better diagnostic assessment tool came from a project we already started named phpAssess which is currently used with authoring tools in middle school mathematics in South Korea. Currently we use phpAssess for mathematics learning, but it could be used for all subjects widely. The following section explains how we integrated the concept of the above stated system (phpAssess) to create a new component on top of Joomla! core that will act as a quiz generator inside the CMS. However, our system is still in implementation phase.

In order to inject the phpAssess into Joomla!, we are going to follow its components classification which imposes two basic interfaces:

- Administrator phpAssess: allows creation of quizzes, viewing students report, modify setting etc...
- Front end: (the quiz itself) student will take online quizzes through this interface, as long as they answer questions, the system will update probabilities for other parts of the students model.

After insertion of this component in Joomla, we can see our new component now in the component list. It contains three main parts: Category management, Quiz management and Reports.

2.3.1 Quiz management

This part is in charge of creating a new quiz and new questions. It handles all quiz details as shown in figure3 as well (passing score, time limit, feedback management etc...)



Bayesian Inference Quiz Maker: Edit quiz

Quiz Details	
Title:	<input type="text" value="Angles"/>
Author:	<input type="text" value="Administrator"/>
Category:	<input type="text" value="math"/>

Figure 3. Quiz generator screenshot: setting up quiz properties

After providing enough information about the quiz, we can insert new questions to the quiz. The component handles multiple types of questions like drag and drop, multiple choice, multiple answer etc... Figure 4 shows the options that quiz generation let us choose from.



Bayesian Inference Quiz Maker: List of questions

#	<input type="checkbox"/> Text	Reorder	Order
1	<input type="checkbox"/> Find the angle "x" knowing that l and m are parallel.	▼	<input type="text" value="0"/>
2	<input type="checkbox"/> Find the angle "x" knowing that l and m are parallel.	▲ ▼	<input type="text" value="0"/>
3	<input type="checkbox"/> ABCD is a parallelogram. Find the incorrect statement.	▲ ▼	<input type="text" value="0"/>
4	<input type="checkbox"/> Refer to the figure below to find the angle $\angle ADC$ knowing that $B =$	▲ ▼	<input type="text" value="0"/>

Figure 4. Quiz generator screenshot: Quiz bank

For each question, we can set-up a score, number of attempts, and list of possible answers. The component also enables insertion of multimedia objects like flash movies or pictures thanks to a WYSIWYG editor that is shown in figure 5.

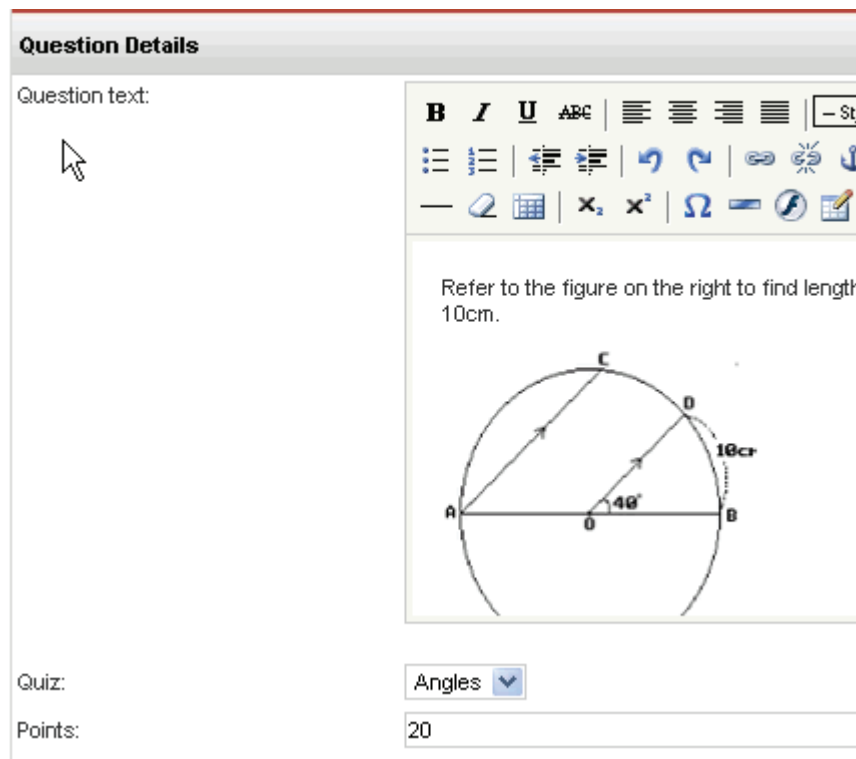
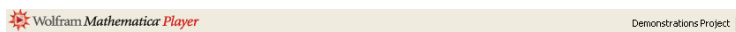


Figure 5. Quiz generator screenshot: Quiz editor

After a question is created, random values are created using WebMathematica, it uses also the correct answer provided by Webmathematica to compare it with the answers provided by the students. A simple function was coded using Mathematica software to generate random numbers and plug them in the question and it also returns the correct answer, a sample code is shown in figure 6.



■ Generating multiple choices

```
genChoice[ans_, delta_] :=
Module[{r, choice}, r = Random[Integer, {1, 4}];
choice = Switch[r, 1,
Table[ans + delta i, {i, 0, 3}],
2, Table[ans + delta i, {i, -1, 2}],
3, Table[ans + delta i, {i, -2, 1}],
4, Table[ans + delta i, {i, -3, 0}]]
]
```

Figure 6. Using Mathematica to generate random multiple answers

2.3.2 Reports Management

Once the quiz is taken by some students, the components keep track of the performance of each one, by saving the time when they took the quiz, their score, time they spent to complete the quiz etc...By keeping such records, we can exploit them for further analysis.

Until now, we have seen how the component handles quiz creation and management. Now we will see how we can exploit the results of those created quizzes and based on previously built Bayesian networks we can draw important conclusions regarding the performance of each student.

We used Netica software and Netica Java API^[6] to analyze our results. First, we draw our Bayesian network that consists of questions and concepts nodes, then we use Netica Java API to extract the network information (which node is connected to each node + prior probabilities).

Once we have our network information extracted, we can run an SQL query to the Joomla! database and extract the quiz results, then, we update the network based on the new quiz results.

After updating the Bayesian network from the new quiz results, the Java Program pops out a Java frame (see figure 7) and draw the newly updated network, it draws also a graph for the concepts related to the quiz and their new respective probabilities (see figure 8). For future work, we going to modify the phpAssess component so as to enter details of concepts related to quizzes instead of reading them from Netica files. We are also going to work on a better feedback based on updated Bayesian networks.

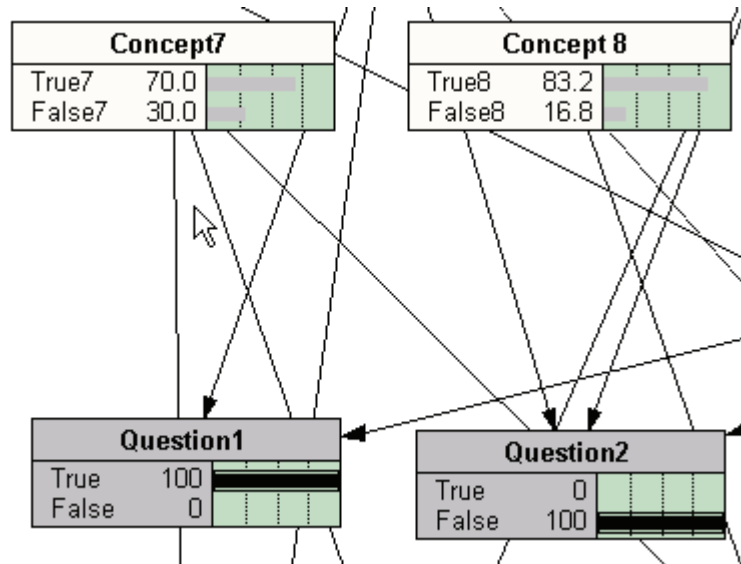


Figure 7. The final updated quiz network after being generated by Netica-API.

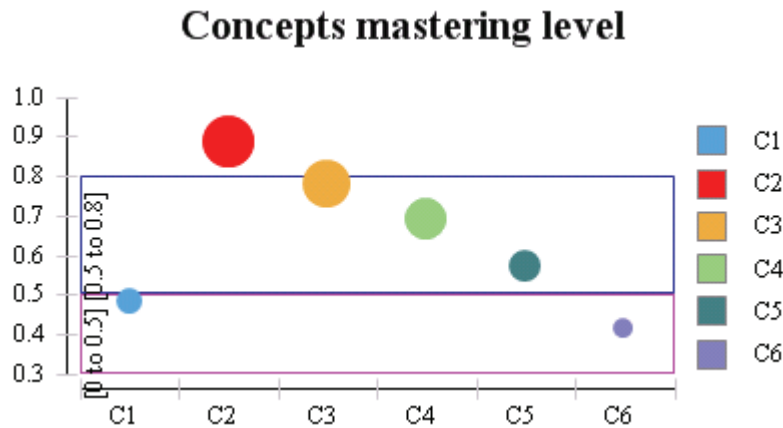


Figure 8. A graph is generated to summarize the new probabilities for each concept.

3 Conclusion and Future Work

The main goal of this paper was to introduce an extension for mathematics learning using online quiz generator using Bayesian inference. The existing open source package of Joomla! is used for this experimental approach, namely extending Content Management System toward Learning Management System. Mathematica turns out to be a quite useful tool for dynamically generating quizzes.

It is noted that Bayesian network based online quiz generator is extended inside Joomla!. The on-line test generated by this tool offers the test score and infers the level of each knowledge item. Therefore the student can select the suitable next step and follow a studying strategy to reinforce his or her weak knowledge items. In this way, diagnostic module is combined with quiz generator for managing individualized learning for middle school math.

For future work, we will test how this approach will work for personalizing processes of mathematics learning. Each student's progress record will be analyzed so that the system can provide adaptive ways of generating quizzes, diagnostic assessment, determining the next sequence of learning path. Along this way, adaptive feedback generation will be an important issue to be followed.

4 References

- [1] Wolfram Mathematica official website. <http://www.wolfram.com/products/mathematica/index.html>
- [2] Jensen, F. V.(1996), An introduction to Bayesian Networks. London : UCL Press Limited.
- [3] Wikipedia: Bayesian Networks. http://en.wikipedia.org/wiki/Bayesian_network
- [4] Mislevy, R.J., & Gitomer, D.H.(1996). "The role of probability-based inference in an intelligent tutoring system." User-Modeling and User-Adapted Interaction, 5, 253-282.
- [5] What is Joomla! (Joomla! official website). <http://www.joomla.org/about-joomla.html>
- [6] Norsys Software Corp. (2002). Netica-J Manual version 2.21 and Higher.