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Using Functions and Cyclic Group in Calculated Questions Moodle 3.2

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Abstract — In modern days, assessment methods are designed in online to enhance its effectiveness among students as well as staff members of the institution. The Learning Management System (LMS) plays a vital role of conducting the assessments through online. This paper discusses the need to have an efficient and systematic usage of LMS, in particular Moodle, for improving the existing assessment methods of mathematics curriculum. Also, various question types which are used to overcome the disadvantages of classical assessment methods, are highlighted and described in detail. The working methodology of such question types in Moodle is explained by using the properties of functions and cyclic groups.

Keywords — Moodle; Calculated Question; Calculated Multiple Choice Question; Wildcard; Cyclic Group

I. INTRODUCTION

In olden days, the principle of education was developing basic inter-personal communication and literacy. Slowly, the purpose for pursuing education has varied with respect to the individuals or the group of people. After acquiring such basic abilities, they are improving the tendency to learn more complex skills and subjects like Astronomy, Natural Science, Mathematics etc.,. They institutionalized the teaching and learning process because they felt that the aim and knowledge of a group of people sustain from one generation to the next. Also the inclusion of assessment is unavoidable in the institutions to improve the methodology of teaching and learning process[10]. Nowadays various types of system of education are followed in the institutions all over the world. In most of the countries, it is compulsory to receive primary education. Based on this methodical education the world obtains good technology to grown-up. The augmentation of every nation is based on the advancement of the technology. Also technology is an increasingly influential factor in education. Technology offers powerful learning management system which is used for teaching as well as assessment. Such tools demand new way, skill and understanding of teachers and students. The use of technology helps in capturing the concentration of students in the classroom and also in assessing them. Since the assessment is also a major part of education methodology, it demands the new ways to assess the students with the support of technology. The usage of LMS is spread rapidly in almost all the institutions around the globe. [1,2,7]

Social interactions that improve the motivation to learn and advance in the educational process take place within the Moodle (Modular Object-Oriented Dynamic Learning Environment) which allows teachers to create web learning groups, offering educational programs, through internet. The teacher can create virtual classrooms and courses, register students, create their profiles, create websites and discussion forums, post educational material, create student groups and assign projects, create, distribute and grade quizzes, and, finally, automatically follow each student's activity. [6] In our work place Nizwa college of Technology (NCT), Nizwa, Sultanate of Oman, we started using the LMS-Moodle 3.2 for teaching the major part of the courses. Along with constructivist views of learning, the assessments of several courses are conducted in Moodle 3.2. In Math section, the continuous assessments of the bridge courses- Basic Math, Pure Math and Applied Math are completely conducted in Moodle 3.2. This was gradually achieved through a continuous effort for the past two years by conducting several workshops for the staff and students. Every semester the feedback collected from the staff as well as students was considered to improve the quality and comfortability of conducting assessments online. In this paper, the usage of mathematical functions and cyclic groups in the calculated question type of Moodle is discussed with detailed examples. The advantages of conducting such quizzes in Moodle for continuous assessment is explained in detail.

II. QUESTION TYPE IN E-ASSESSMENT

e-Learning will continue to grow in our institutions. In anticipation of this growth, we can start focusing on application and the effective and efficient implementation of e-assessments. By recognizing that e-learning truly is a methodology, one can experience the greatest benefits that e-assessment has to offer now and in the future in Moodle. [8]There are a variety of default standard question types available in the Moodle which can be used in assessments. These include Calculated, Calculated simple, Calculated Multiple choice, Description, Essay, Matching, Embedded answers, Multiple choice, Short answer, Numerical, Random short answer, True/False, Drag and drop, and select missing words types of questions. Apart from these default standard question types, there are a variety of question types available as add-on's like Geogebra, Stack, formulae etc. [3, 8]. In NCT, the focus of the Math section is on creating assessments using the Calculated multiple choice type questions and the calculated type questions in Moodle.

The reason is that the calculated question type provides the flexibility of creating a question in which the numerals appearing in the question will be different, resulting in a different question with a different answer, for each student. The answer options of a multiple choice question can be shuffled so that each preview of the question in a quiz has the answer options displayed in a different order. This will help to prevent plagiarism and increase the standard of assessments. Also, Moodle provides the flexibility of giving any mark from 0% to 100% for an answer option. The advantage of this is that answers which are partially correct can be graded partial mark.

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The Math section of NCT uses five answer options for a calculated multiple choice question with one correct and maximum one partially correct answer. If more number of partially correct answers are included, the number of answer options is also increased so that not more than 50% of the total options are marked partially correct. Short answer questions are created using calculated type question wherein the student has to enter the answer as a value in the box provided. This type of question also provides the flexibility of allotting partial marks to the answers, ranging from 0% to 100%, depending on the degree of correctness of the answer. There is provision to give as many possible partially correct answers which are caused due to a small calculation mistake/ formulae error. The partial marks can be pre allotted in the question setting during the creation.

Long answer questions are created using calculated as well as embedded answers/ cloze questions. Embedded answers/ cloze questions is a question type in which a series of questions can be asked as multiple choice, numerical response type or a short answer type question. A numerical response type question is a question which accepts a number as a response to a question whereas a short answer type question is one which accepts one or a few words as answer response. Embedded questions are fixed response questions. The quiz setting in Moodle allows the flexibility to choose a random question from a folder in the question bank. So when an embedded answers/ cloze question is created, it is kept in a separate folder and multiple copies of the questions with different numerals are created along with it in the same folder. When conducting a quiz, a random question is included from this folder as a long answer question. This will help reduce plagiarism.

A. e-Assessments through Moodle in NCT

Even though NCT started using the Moodle platform a decade before, the Math section of NCT has started using it as a platform for conducting e-assessments only for the past couple of years. The continuous assessments for the Math bridge courses- Basic Math, Pure Math and Applied Math are being carried out in LMS-Moodle. There are three types of continuous assessments for these courses in NCT - Class Activity, Assignment and Test. There are five class activities for two marks each, two assignments for five marks each and two tests for twenty marks each. The class activities and the assignments are scheduled to be done outside classroom whereas the Tests are conducted inside labs within a specific schedule. All the assessments are created as quizzes in Moodle. The quiz setting gives the flexibility to make several restrictions to the students in order to reduce plagiarism.

The class activity is a timed quiz for 20 minutes which forces the student to navigate sequentially from one question to the other. This helps reduce the plagiarism to an extent as the class activities are scheduled outside the classroom. The assignment is not time bounded, yet it forces the student to navigate sequentially from one question to the other. The student is given a chance to attempt the assignment twice and the best mark among the two attempts will be considered. The Test is a timed quiz for one hour scheduled to be conducted in computer labs with the help of invigilators. In tests, the students are allowed to navigate freely from one question to the other.

B. Advantages of e-Assessments through Moodle

The following are the advantages of conducting assessments through Moodle.

a) In quiz activity settings, there is an option to shuffle the questions so that the neighboring students get the questions in different orders while attending the quiz.
b) In question settings, there is an option to shuffle the answer options in the multiple choice questions so that the neighboring students get it in different orders while attending the quiz.
c) Each question is taken from a dataset of 100 values. So the combination of questions each student gets will be different. This prevents plagiarism.
d) To completely avoid malpractices, all the possible protection available in version 3.2 of Moodle like time restriction, password protection, network IP restriction (activity available only in computers that are connected in the LAN of NCT), full screen popup with java script security are given.
e) Partial marks can be awarded to the partially correct answers, depending on their degree of correctness, which makes the online activity equivalent with paper marking in terms of short and long answer questions. Moreover, uniformity in marking can be achieved using online assessments.
f) Students can review their answers after the closing time of the quiz. They can also view their respective quiz marks immediately after submission of quizzes.

III. MATHEMATICAL FUNCTIONS

In Mathematics, a function is a relation between a set of inputs and a set of permissible outputs with the property that each input is related to exactly one output. In addition to simple arithmetic operators, the available mathematical functions (https://docs.moodle.org/22/en/Calculated_question_type.) can be used to create calculated and calculate multiple choice questions in Moodle version 1.5 or newer. [3]

Table 1:Structure of the E-Assessment in NCT

Outside Class Activities				
Assessment Activity	***No. of Questions***	***Calculated Multiple choice***	***Embedded Answers***	***Matching***
Class Activity	4	4	-	-
Assignment	8	6	1	1
Inside Class Activities				
Tests	***No. of Questions***	***Calculated Multiple Choice***	***CMC and Calculated / Embedded***	***CMC and Calculated / Embedded***
Objective Type	5	5	-	-
Short Answer	4	-	4	-
Long Answer	1	-	-	1

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IV. CYCLIC GROUP

Consider the natural mapping $\eta: Z \to Zn$ which maps each integer m to its congruence class m modulo n. If a group is cyclic, then there may exist multiple generators for a cyclic group. For example, Z_5 is a cyclic group. The element 1 is a generator for sure. It is easy to check 2 is also a generator for Z_5. So all the group elements {0,1,2,3,4} in Z_5 can be generated by 1 as well as 2. Since every non-zero element generates Z_p when p is prime, all the group elements {0,1,2,3,4} in Z_5 can be generated by all the non-zero elements 1,2,3 and 4.

By using the basic principles of cyclic groups, it is possible to generate the numbers of the set $\{0, a, b\}$ by the function $f: \{0,1\} \times \{0,1\} \to \{0, a, b\}$ defined as $f(x, y) = x \times a + y \times b$. The domain of this function depends on $fmod\ (n, 2)$ where $fmod(p, q)$ is float mod function which gives the remainder when p is divided by q. [9]

V. WILDCARD

Calculated type questions uses wildcards, which are independent variables that take a random value from a predefined dataset of numbers, during the test. The dataset for the wildcards are classified into two: private data set and shared dataset. A private data set is used in case of a single question without any sub-divisions. A shared dataset is used in cases where the main question has two or more sub-questions where the data are being shared. In such cases a shared dataset for the wildcards used in the question is created along with the main question and is synchronized to be used with the sub-questions. Once a shared dataset for a wildcard is created, it can be synchronized and used in the sub-questions. Short and long answer type questions are given to the students using calculated question type with two or more sub-divisions, using a shared wildcard. The maximum possible values in the dataset of a wildcard are 100. It means Moodle database can generate maximum hundred different set of wildcard values which results in maximum hundred different questions that takes the wildcard values from a particular predefined range. The wildcard values can be integers or decimal numbers up to ten places of decimals. [3, 4 ,5]

A calculated multiple choice question is created with five answer options. The answer options should be made with the help of the Moodle special functions on the wildcards used in the question. The main challenge with creating a calculated multiple choice question is that the answer options are to be framed in such a manner that none of the answer options gives the same value with any of the dataset values ranged in the wildcards. For this, the five answer options are to be considered as five different mathematical functions and the wildcard values should be chosen so that the range of these five functions does not have any value in common.

In general, the answer options for most of the questions can be obtained by using the direct formulae. The partially right options as well as wrong options also can be obtained by the direct formulae. There are some questions with integer answers which vary from 0 to $n > 0$. On close observation it can be seen that these are simply elements of the cyclic group Z_{n+1}. Such questions can be created with the support of the properties of cyclic groups. In the next section, a few examples are given which requires the properties of function and cyclic groups.

VI. EXAMPLES

Here are some examples where properties of cyclic groups are required to frame the questions. It enhances the quality of the question. Example 1 is a calculated type question created in Moodle by using cyclic group.

Example 1.
Suppose a, b, c, m, n are non-zero integers with $m, n > 0$. The curve $ax^m + by^n = c$ is symmetric with respect to -

- 1 - x-axis only
- 2 - y-axis only
- 3 - all of x-axis, y-axis and origin.
- 4 - none of x-axis, y-axis or origin.

The right answer is generated by

$$1 * fmod(\{m\},2) + 2 * fmod(\{n\},2) + 1$$

This answer option has the values that can be thought of as elements Z_4 with one added to them. So for creating answer options for this question, a function which generates all the values of Z_4 has to be defined. This can be done using the '$fmod$' function. The following example is a calculated multiple choice question type which is created in Moodle by using cyclic group.

Example 2.
Suppose a, b are two non-zero real numbers and p, q are two positive integers. Name the quadrant in which the point $((-1)^p a, (-1)^q b)$ lies.
Depending on the values of p and q the point can be in any one of the quadrants 1, 2, 3 or 4. These values can be generated using elements of Z_4 with one added to them. So for creating answer options for this question, a function has to be so defined which generates all the values of Z_4. This can be done using '$fmod$'function. The right answer option is the number generated by

- $Quadrant\ \{= fmod(\{p\},2) + 2 * fmod(\{q\},2) - (fmod(\{p\},2) - fmod(\{q\},2)) * fmod(\{q\},2) - fmod(\{p\},2) * fmod(\{q\},2) + 1\}$

As it is a calculated multiple choice question, it is mandatory to give wrong answer options. This question is different from the usual calculated multiple choice question where the right answer option can be a value derived from formulae function and the wrong answer option can be any value derived from any other distinct formulae function. Here the wrong answer options should be meaningful, for instance, if the right answer option is "Quadrant 3", then the wrong answer options should contain "Quadrant 1", "Quadrant 2", and "Quadrant 4". To generate such wrong answer options, the following formulae used.

- $Quadrant\ \{= fmod(2 * (fmod(\{p\},2) + 2 * fmod(\{q\},2) - (fmod(\{p\},2) - fmod(\{q\},2)) * fmod(\{q\},2) - fmod(\{p\},2) * fmod(\{q\},2) + 1),5)\}$
- $Quadrant\ \{= fmod(3 * (fmod(\{p\},2) + 2 * fmod(\{q\},2) - (fmod(\{p\},2) - fmod(\{q\},2)) *$

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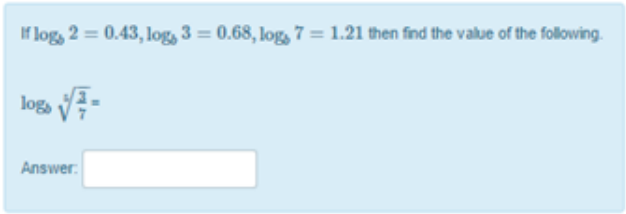
$fmod(\{q\},2) - fmod(\{p\},2) * fmod(\{q\},2) + 1),5)\}$

- $Quadrant \{= fmod(4 * (fmod(\{p\},2) + 2 * fmod(\{q\},2) - (fmod(\{p\},2) - fmod(\{q\},2)) * fmod(\{q\},2) - fmod(\{p\},2) * fmod(\{q\},2) + 1),5)\}$

The above mentioned right and wrong answer options formula which gives always the shuffled options as "Quadrant 1", "Quadrant 2", "Quadrant 3", and "Quadrant 4". This is created by the idea of functions and cyclic group.

Example 3.

For given $f(x) = a, f(y) = b$ and $f(z) = c$, constructing the question which includes x, y or/and z, and answer options includes a, b or/and c. For example, In the question text, the value 2 and 3 is varied by wildcard {b} in the following LaTeX command



$$\(\log_b \sqrt[\{a\}]{\frac{\{b\}}{7}} \)$$

The correct answer option is
$(0.43 * fmod(\{b\} + 1,2) + 0.68 * fmod(\{b\},2) - 1.21)/\{a\}$

VII. CONCLUSION

The Moodle is an e-learning platform used throughout the world in several universities, colleges, communities, schools and training institutions. This paper has presented the assessment module of the Math bridge courses of NCT as well as enhancing assessment mechanisms by using Moodle quizzes. Moodle quiz, which is the e-assessment of new era, has option to include variety of question types such as true or false, matching, numerical, calculated simple, calculated, essay, short answer and calculated multiple choice etc. The requirement of function and cyclic group in creation of calculated question and calculated multiple choice question is explained in detail with the examples. Apart from creating simple direct formula based calculated and calculated multiple choice questions, these examples shows the importance of using the basic principles of cyclic groups to elevate the quality of assessments using both these question types. It can be considered as a convenient and interesting activity to update the students on their performance throughout the learning process. For the faculty, the time taken to evaluate the assignment is reduced and also for student the uniform marking is possible through Moodle. We are also planning to add a wider variety of questions such as stack, geogebra, formula question type etc. and to include all the possible partial marking in the future quizzes.

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