Abstract— Conducting objective-type exams using online testing tools is becoming popular in academics as well as corporate. This increasing popularity is due to the various benefits offered by such tools such as reduced time and effort due to automated evaluation of objective-type questions; ease in analysis of exam data stored in electronic form, availability of sophisticated reports and statistics, auto-update in the grade book, question banking facility, etc. But, often objective-exams are still conducted in an offline mode – using OMR sheets for example, mainly due to infrastructure constraints, lack of technical support, security and recovery concerns, etc. It will be useful if such offline exams can also utilize the benefits offered by an online testing tool. However most of the existing online testing systems provide support for only completely “online” exams.

In this paper, we describe our attempt to extend “Quiz” module in a popular learning management system “Moodle” to support offline objective-type assessments. Support for such offline assessments in an online tool introduces its own challenges such as generating variants of question papers from one master question paper to reduce cheating, converting the papers in a printable format; diagnostics of uploaded answer-sheets data to detect syntactic errors, facility to correct any incorrect information in the answer-sheet – such as incomplete student id, duplicate student id, etc; maintaining various versions of the answer-sheet; post quiz analysis of questions in the master question paper; facility for faculty to suggest certain changes as per the analysis such as cancelling a question, including an alternate answer, etc; ensuring changes in the master question paper is reflected in all variants; reprocessing the results with the updated question paper data, etc. We look at these concerns in detail and describe how our extension to Moodle addresses these concerns.

I. INTRODUCTION

OBJECTIVE type tests are commonly used for competitive exams, pre-recruitment tests, certification exams, entrance exams, etc. Such exams generally have large number of candidates appearing and require the results to be published fast. Hence there is a preference for objective type tests. Objective type tests mostly consist of Multiple Choice questions (MCQs). Other variations of Objective type tests are fill-in-the-blanks, true-false, and matching items [1]. In this paper, we will restrict our discussion to Objective type tests containing MCQs only.

MCQs are easier to guess and easy to cheat since answering such question consists of just selecting one of the given options and thus students can copy each other’s answers [3]. To reduce these attempts of cheating, sometimes different variants of question paper are generated, each containing same questions but scrambled. Another issue in MCQs is chances of ambiguity in the question paper or the answer options. The analysis post evaluation can be useful to address this concern. This analysis is generally done by analyzing the responses of the top scoring/all students for a question to the respective correct option. The analysis can be used to detect errors/ambiguities if any in the question paper (question text, answer options) [2] and accordingly corrective actions can be carried out to fix the ambiguities so that the students are not penalized due to error in the question paper.

A. Modes of Conduction

Such tests are usually conducted in one of two ways. In mode 1, what we can call online mode, a paper is set online, students are shown the questions on the computer and answers are marked in the computer. In mode 2, a computer system may be used for setting a paper and computing marks, but students mark their answers on paper – usually an Optical Mark Recognition (OMR) sheet – based on a hard copy of question paper. We use the term offline to denote this mode.

In online mode, the student has to login to the testing software using a terminal or web browser and answer questions on the computer directly. Most of the tools facilitate auto-evaluation of objective type tests and hence it is possible to declare the results and feedback immediately. After the tests are scored, the data can be updated/downloaded into an electronic grade book. Online testing also eliminates the need of material infrastructure such as question paper, answer sheets, printing and transportation, etc.

Conducting an exam in online mode introduces some challenges which cannot be overlooked [4]. A competitive exam, for example, typically has hundreds of students giving
the exam together. However many organizations do not have infrastructure and required technical support to conduct the exams online for hundreds of students at once. In online testing, though the exam can be conducted online, it needs to be done under supervision to avoid unauthorized access and cheating. The security mechanism needs to be robust enough so as to avoid intrusions, unauthorized access, avoid loss of data, hacking of the system, etc. Similarly the system also requires a good recovery mechanism to ensure proper recovery of the system incase of network or browser crash during the examination. We also need good network connectivity for online tests.

Because of these issues, most of the organizations prefer to conduct exams in an offline mode. OMR-based exams [5] facilitate getting exam data in electronic format for further processing and hence appear to be a good option for reducing the time and effort in offline exams. OMR-based exams, however, have low tolerance level of student mistakes such as improper/missing ovalling. It fails to read improperly ovalled entries, this can result in erroneous exam data. The question paper also needs to be prepared taking into account the structure of OMR sheet or OMR sheet needs to be in sync with the structure of exam and question paper. If its concerns are addressed and the concepts of online testing such as auto-evaluation, question banking, etc can also be brought in – this together can definitely lead to increase in the efficiency and reliability of the tasks involved in offline testing. Essentially we are looking out for an online tool which can bring in best from both of the worlds (offline testing and online testing) for managing offline exams. That is, the tool must have features supported by online testing tools and should also address the concerns of OMR-based testing.

In the next section we will study some existing tools which provide support for online/offline exams. We evaluate these tools against our requirements and subsequently arrive at our proposed system. Section III discusses our approach to implement the proposed system as an extension to a popular LMS, Moodle and also looks at the implementation aspects. Section IV talks about the current status and looks at future directions.

II. ONLINE SUPPORT FOR OFFLINE TESTS

A. Requirements

Based on need identified in the previous section, we are looking for an online tool which will fulfill basic requirements of an exam conducted in offline mode such as - creating/managing questions; creating/managing question paper; converting question paper in a printable format; processing of scanned OMR data - to detect and rectify errors in scanned OMR data due to improper ovalling and to do result processing as per the question paper and keys; facility for post evaluation analysis of questions/question paper; maintaining results in grade book, etc. We will now evaluate some existing tools against our requirements.

B. Existing tools

Many tools are available that provide support for managing and conducting Online Tests [6]. These tools are either independent testing tools such as Veda [7], Zoho Challenge [8] or are part of assessment mechanism in a Learning Management System (LMS) such as Moodle [9], A'Tutor, etc. These tools provide various facilities that increase the efficiency of managing and conducting the tests online. The effort and time required for evaluation is substantially reduced as these tools automatically evaluate objective type questions. Also these tools have advanced reporting and analysis mechanisms which provide useful statistics of the result data post evaluation. Some tools also have the facility to shuffle questions of a quiz – this can reduce the attempts of cheating in an online test.

Most of the available tools, however, do not have a support for offline exams. Moodle [9], has an option for offline assignment and also provides other rich assessment features. Assignment Module [9] in Moodle, allows teachers to collect work from students, review it and provide feedback including grades. In “Offline” type of assignment the teacher has to provide only description and due date in Moodle. The actual conduction of the assignment as well as grading is done out side to Moodle. Later the grades and student specific feedback can be recorded in Moodle. However assignment module is focused on descriptive type questions only and does not have any support for maintaining questions/question bank independently and also post-evaluation analysis of question, question paper. There is no “offline” option in Moodle “Quiz” module which handles Objective type tests.

There is lot of online support available for managing OMR-based exams. Most of the support is available in form of services provided by different vendors [10] [11] [12]. These vendors offer services such as creation of custom OMR sheet, scanning of the OMR answer sheets after the examination, processing of this scanned data to obtain results, generating specific reports from the result data, etc. Apart from services, there are also downloadable software such as Remark Classic OMR [13] and Vision OMR Software [14] available for handling the OMR-exam related tasks.

C. Observations

The Online Testing tools available today are focused on online tests only. There is no testing tool/LMS known so far which has support for OMR-based exams as outlined in the sub-section II.A.

In such a scenario, one option to exploit benefits of testing tools as well as OMR-based systems would be to integrate both. For integration we will require source code of both the tools to be available with us. While we have lot of open source testing tools and LMSes, OMR-based tools/services are still proprietary and closed source.

Taking in to account the limitations of the existing testing tools and OMR-based tools we have built a system to provide online support for objective-type exams conducted offline (OMR-based exams). The tool will extend an existing open source testing tool to support OMR-based exams and will also...
address the issues in OMR-based exams such as answer sheet data error detection and rectification. As of now, we have chosen the extension to be based on the format of exams conducted for C-DAC Mumbai’s diploma programme [15]. Further, the testing tool chosen for extension is popular LMS Moodle [9].

D. Why Moodle

Moodle is an open source, easy to extend and customize, Learning Management System. Along with comprehensive online documentation, there is lot of support available from the active online community regarding using/customizing/extend Moodle. “Quiz” module in Moodle, which is focused on objective type tests seems appropriate for our requirements. It provides rich features such as question banking, import/export questions, shuffling of questions, “Item analysis” and Report generation, post evaluation which can be used for offline tests too. Also Moodle is already used in our diploma programs, so the faculty and students of our diploma program are already familiar with it. This extension will result in reduced time and effort as well as increase reliability of all the tasks involved in managing OMR-based exams. Also since there is no support for offline exams (objective) in Moodle, this extension will be useful contribution to the Moodle community as well.

III. OUR APPROACH

As mentioned in the previous section the format of the system is based on our diploma program. In this section we will first discuss the structure of our diploma program exams, accordingly arrive at the exact requirements and then discuss the methodology adopted for extending Moodle to support these requirements.

A. Scope

Structure and Processing tasks of our OMR-based exams

Our course quizzes are objective type tests consisting of multiple choice questions (single correct answer). These are conducted in a proctored environment on OMR sheets. The OMR sheet and the paper pattern (number of questions, number of options, student information required, etc) are in synchronization with each other. Variants of question paper (booklets) are created manually to avoid attempts of cheating. Each booklet is associated with a unique id.

After the exams, the OMR sheets are scanned with a specialized scanner to obtain the answer sheet data in an electronic format. In the scanned file, each record holds data of a specific OMR sheet such as name, student id, booklet id, and answer string. This scanned data is analyzed to detect any errors such as invalid or missing booklet-id/student-id, duplicate ids, etc due to improper ovalling in the OMR sheet. After initial evaluation, analysis of results is done to detect errors/ambiguities in question/question paper. If required, corrective actions are taken post-analysis. These corrective actions include cancelling an ambiguous question or providing one or more alternate answer for a question.

Thus the entire processing of scanned OMR data comprises - detect and fix errors (if any) in scanned OMR data, evaluation of answer sheets, analysis of results and updating of result in student database. The existing setup for handling the processing tasks is quite time and resource consuming as these tasks are handled by separate teams using separate legacy systems. Generating variants is done manually and hence is tedious to create/update all variants of the question paper, especially when there are any changes in the master question paper.

Requirements in detail

Considering the structure and stages of result processing in our exam - we arrive at a set of requirements to be fulfilled by the extension to Moodle quiz to support our OMR-based exams. The extension in Moodle “Quiz” should allow the faculty to:

- Maintain questions in the question bank
- Create master question paper using the questions in the question bank
- Generate variants (booklets) of the question paper i.e. shuffled versions of the same master question paper, each associated with a unique Booklet id.
  - Variants to be available in printable format
- Upload configuration of the OMR sheet to Moodle – such as position and length of booklet id, position and length of answer string, etc.
- Upload the scanned OMR (containing the student answer strings) file to Moodle
  - Moodle to retrieve appropriate data from the scanned OMR files as per the configuration information.
- Perform analysis of the scanned OMR file to diagnose errors in answer-sheets such as duplicate ids, missing booklet ids, missing student ids, etc.
  - The errors (if any) should be displayed.
  - Facility to update the answer sheet data by rectifying errors (if any).
- Analysis of exam data to detect ambiguities (if any) in the question paper
- Perform corrective actions on the master question paper (if required)
  - Cancel a question or Provide alternate answer
- Reprocessing for all the variants if -Answer sheet data changes, OMR configuration changes, master question paper changes, etc
- Publish the results - Student grade book to be displayed only when results are published

The requirements are illustrated in Figure 1.

Apart from the above requirements, one significant requirement is that relevant facilities available to online version of the Moodle Quiz should be present in this proposed “Offline” version too.
Challenges in Requirements

We can observe some challenges in the requirements that we just derived from our needs. Rectification of errors in answer sheet data would require handling multiple versions of answer sheet data. The processing of results needs to be done only for valid answer sheet records (valid students, valid booklet ids, etc), else it will lead to erroneous results. Before the corrective actions are done there should be some provision to store the original question/question paper as well. Similarly reprocessing of results would be required when there is any change in the answer sheet data, OMR configuration changes or any corrective actions have been performed on the original question paper. This would result in multiple versions of student result data. Last but not the least is the requirements which need all the facility of Moodle Online Quiz to be available for the Offline version too. The next subsection discusses the methodology for adapting these requirements in Moodle quiz and also looks at how the above mentioned concerns are addressed in our system.

B. Methodology for Extension

To decide on the methodology for the extension, we first studied how Moodle handles processing of online quizzes. In an online quiz, when a student submits a quiz, Moodle processes that attempt data using the quiz questions from the question bank. This processing phase evaluates each question, does the mark calculation and scaling (if required) and updates the student grade book. It also performs analysis on student data to obtain sophisticated item analysis and also generates various reports on demand. Online student attempt data and questions in the quiz are required as input in this phase. Considering this scenario, our methodology for extension is to introduce some mechanism to feed in the offline attempt data to the processing phase of Moodle. If we are able to do that, the processing phase will take care of doing rest of the activities such as Item Analysis, Updating in grade book, etc.

Requirement Mapping

Now that the requirements and methodology is clear, we now focus on how this requirements and methodology can be built on top of Moodle Quiz. We analyzed each requirement to check – Which part of Moodle Quiz can be reused or adapted for that requirement. Requirements, which did not have a suitable match to Moodle Quiz functionality, are built from scratch. This mapping between our requirements and Moodle Quiz functionality is listed in Table 1.

The next sections throw light on how various requirements are adapted in Moodle’s Quiz module.

Moodle Quiz Adaptation

Quiz is extended to support another type of exam –i.e. offline, OMR-based exam. The name of this new quiz type is “OMR”. “OMR” type of quiz inherits all the functionality of Online version of the quiz and provides additional OMR-specific functionality such as uploading OMR configuration, generating/maintaining variants of the question paper available in printable format, upload of answer sheet data, processing of results and publishing of results. While creating the quiz, the parameters that require being set are “opening of the quiz” and “Time limit”. The opening time and date and time limit is displayed on each variant in printable format. Rest of the parameters can be default. The adaptation of this parameters is also consistent with the interpretation and impact of these parameters in “Online” Quiz. Considering the interpretation of these parameters in Online quiz, the attempt data can be uploaded in Quiz and processing of the quiz can be done only after the opening quiz date and time, respectively.

So, essentially, after the processing is done, there will not be any difference between the student exam data – whether the student has attempted it online or has attempted it offline. The
Configuring OMR Parameters
OMR parameters such as answer-string position, booklet position, student roll number position, etc. are uploaded as a text file. This helps the processing functionality of Moodle to retrieve relevant information from the uploaded scanned OMR files. It also facilitates the OMR structure to be flexible. If the OMR sheet structure is changed, relevant parameters in OMR configuration file can be updated.

Question Paper Variant generation
Given the number of variants, booklet ids for the variants can be entered manually or generated automatically. Care is taken to ensure that variant ids are unique across Moodle to avoid clashes in answer sheet data across quizzes. The shuffling of questions can be done automatically or manually (using Moodle’s inbuilt reordering tool). The shuffled version of the question paper includes the original question ids in a shuffled order. This ensures that any change in the master question paper/questions is reflected in all the variants. All the variants are also available in printable format. All this saves faculty effort to do these tasks manually. If a question is added to question paper post variant generation, this question is appended at the end of the question list in every variant. If required, the faculty can do further shuffling.

Uploading the Offline Answer Data
OMR scanned data files can be uploaded in Moodle for further processing. Relevant information from each record is retrieved as per the OMR configuration information. First each record is scanned to detect errors due to improper ovalling and the respective errors are displayed either error category wise or record wise. For rectification of errors, the faculty is expected to make changes in the answer sheet data file as per the diagnostic information and accordingly re-upload the answer sheet data. When the faculty uploads updated answer sheet data, all the previous data is cleaned and substituted with the newly uploaded data.

Processing and Publishing of Results
As per the requirement, the results are processed only for valid records (valid student ids, valid booklet ids, etc). Moodle process functionality is adapted to do the processing. As mentioned before the offline attempt data i.e. the scanned OMR data is provided as an input to the processing functionality. This ensures the processing of the results and the corresponding updates in Moodle are done as in case of an Online “Quiz”. However, result changes in the grade book are not visible to the student after initial processing of results. The result changes will be visible to the student in the grade book only after explicit “Publishing” of results. This is to allow faculty to review performance statistics and make modifications as shown in next sub section.

Analysis of Results
After the initial processing of results, Moodle’s inbuilt “Item Analysis” can be used by the faculty to identify ambiguities (if any) in the question paper. In Moodle’s Item analysis, statistical parameters used are calculated as explained by classical test theory [16]. Among the various statistical parameters available, “%R” can be used to detect ambiguities/error in a particular question. “%R” denotes the number of students that opted for the correct option. So if majority of students select an option other than the correct action - the question is ambiguous OR there are more than one correct answers for this question OR there might be some error in setting correct answer in master question paper.

Corrective Actions
The faculty can check the analysis and as per the values of various parameters in the Item analysis table, take appropriate corrective actions. For cancelling a question – zero credit can be given to the question in the master question paper or full credit can be given to all options in the question in the master question paper. For including an alternate answer for a question, full or partial credit can be given to respective alternate answer in the master question paper. Moodle already support all this manipulation at question level. Whenever corrective actions are applied on a specific question, the original question gets changed. However all the corrective actions applied to that question are stored along with that specific question, for that particular quiz, for further reference.

Reprocessing
Reprocessing of results is required when answer sheet data is re-uploaded or variants are changed or OMR configuration is changed or Corrective Actions are performed on the question paper, etc. The reprocessing policy we have adopted is - Clean old data and process freshly with the new data.

C. Implementation
Moodle is modular in structure and all the files related to Moodle “Quiz” are organized in a separate “Quiz” module folder. Most of additions/modifications done for this extension
are limited to this folder only. Various conventions are followed to ensure version compatibility. Available global variables are used to retrieve user information, get database connection, etc. Similarly Moodle coding guidelines are followed. Wherever required Moodle’s library functions are used for accessing database, etc. Currently the interface of this extension is available in English language only but it can be localized later as the content of the interface is stored and manipulated in form of language strings.

IV. CURRENT STATUS AND FUTURE WORK

The requirements have been implemented till the stage of publishing of results. We are currently testing the system with actual OMR exam data. Once the testing phase is completed, we are planning to release the beta version for evaluation by Moodle community. After the evaluation phase, we will contribute it to the Modules and Plug-ins in Moodle. We are also planning to send it for evaluation to potential users such as educational organization, corporate which are already using Moodle.

While the implemented system is useful, it can still be extended to make it more extensive to support offline objective-type exam. Some of further work includes – supporting complex OMR formats, support for multiple correct options in MCQ, making the system available as a web service which can be integrated by any LMS, CMS, etc.

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