

State of the Art Technique for Recognizing Understanding of Learners'

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Abstract: Online Multiple Choice Questions (MCQ's) Exams have been used as a medium for assessing the proficiency of individual in school, colleges and corporate. The results of the exams conducted are commonly used for promoting the student to the higher class or for competition to decide the aptitude of individual for employment. The report hardly provides any insights for identifying the concepts that students' have not understood properly and required to be re-explained or further discussed. The system discussed in this paper customizes the online MCQ's exam system and generates variety of reports. These reports makes the system useful not only for assessing the proficiency of students'/trainees' but also help the teacher/corporate trainer in recognizing their true state of understanding for the knowledge shared in class/corporate training.

Keywords: Online Examination, Assessment, Evaluation, Understanding, Doubts, Queries, Student, Teacher, PARAM, Rule Based Reasoning, Multiple Choice Question.

I. INTRODUCTION

The online MCQ's exam system's answers are traditionally evaluated only as right or wrong, giving full marks for correct answer and zero marks for incorrect answering e.g. MHT-CET (Maharashtra Health and Technical Common Entrance Test) [1]. Further, some online MCQ's exam systems keep the negative marking scheme (subtracting some percentage of marks allocated to the question from the total marks obtained) for answering wrong to prevent false positive assessment of the individual's aptitude e.g. JEE MAIN (Joint Entrance Examination (Main)) [2]. This approach of evaluation provides proficiency of the individual in terms of numerical score. This numerical score is also sometimes converted into percentile system (relative aptitude of students who appeared the exam). The numerical score or the percentile score at end is used for comparing the aptitude or of the individuals. Getting the answer correct especially in MCQ's doesn't guarantee that student have really understood the concept properly, it may even be some guess work or approximation.

The MCQ's type of exam system and its evaluation technique is therefore required to be enhanced, such that it helps teacher/corporate trainer recognize from their side whether students actually understand, exactly what they are teaching. It is observed that students'/employees' don't ask their doubts in class/corporate training due to shy nature or fear of bad impression among peers and in front of teacher and sometimes doubts are unclear due to poor concentration. Hence the doubts remain unsolved. To address this requirement of enhancing the MCQ's exam system and its evaluation technique such that, it helps recognizing the true state of students'/trainees' understanding, a model was proposed in [3].

This paper provides the details of implementation, results and analysis of the model proposed in [3]. The remainder of the paper is arranged as follows: In section II, Literature Survey is discussed. In section III, Proposed Approach with Implementation Details is discussed. Section IV outlines Experimental Setup and Report Analysis. Section V discusses Conclusion and Section VI provides the Future Scope.

II. LITERATURE SURVEY

In [3], Vrajesh Doshi and Bidisha Roy have proposed an algorithm called 'PARAM'- Performing Assessment using Rule based reasoning And Machine learning. The input for this algorithm is generated using a customized online exam system and output are custom reports which help the teacher/corporate trainer recognize true state of students' understanding. If the teacher finds that the students' have not understood any concept well by viewing the custom reports, then teacher discusses and clears those doubts of the students' by interacting with them at group level or individual level. The system requires to be validated by an expert (teacher/corporate trainer) by conducting a test on the specified customized online exam system, for custom reports providing true positive results by interacting with the students'.

In [4], Shitanshu Mishra and Mukulika Maity have provided a system where student can post their doubts or questions and priority for solving them. The teacher classifies the doubts as clarification or exploratory or irrelevant. Teacher first solves out clarification doubts then the exploratory doubts depending on priority of questions.

The system can't tell from its side about the confusion or doubts if student fails or forgets to ask.

In [5], Manisha Das et al. propose that there occurs significant improvement in performance especially of the students scoring less than 50% marks if they are re-taught and then made to re-appear for the exam instead of making them re-appear for the exam without re-teaching them. Here, the re-teaching program gets conducted in same way as taught for the first time. Students may get doubts even in the re-teach program, if students' fail to clear such doubts or missed concepts due to lack of concentration, then no intermediate attempts of identifying such doubts are made by the teacher during re-teach program, due to which certain doubts may remain unsolved.

In [6], Mustafa Yağci and Menderes Ünal propose an Adaptive Online Examination System. In this system initially, student is asked a question with moderate level difficulty. If question is correctly answered by the student then the next question asked will have higher difficulty level else will have lower difficulty level than the current question. The exam will terminate when swinging of difficulty dampens to a specified threshold or when some minimum and maximum number of questions are answered. Here, all students don't get same question to attempt, as question appear dynamically based on previous answer, so comparing gain of students is not possible. There are chances of student not getting the question which he/she can answer from the questions in database. This may falsely evaluate the competence of the student. The system doesn't provide the insights of the knowledge, the student have not gained or the concepts, that are not properly understood.

III. PROPOSED APPROACH WITH IMPLEMENTATION DETAILS

Fig. 1 shows the block diagram of the proposed approach as in [3].

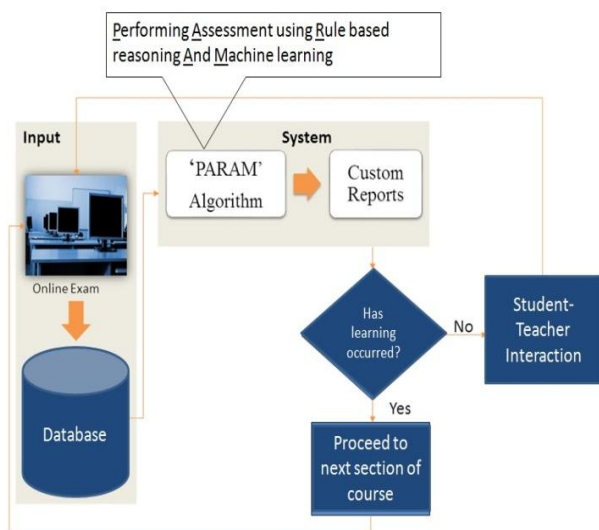


Fig 1 Learning Assessment System

A. Input

The input to the 'PARAM' algorithm [3] is derived from the data generated and stored in the database by conducting an online exam using the customized online examination system whose GUI is shown in Fig.2. For appearing the online exam, student/trainee needs to enter the PID (Personal Identity number), Password, and a common test pin (5 character alphanumeric value) which is announced by the supervisor. This pin is reset in the system as soon as exam gets over, to prevent future attempts of appearing the same exam. The terms 'student' and 'trainee' will be used interchangeably in following sections of the paper.

The features of the above customize online examination system are as follows:

1) Question Panel:

- Present on the left side.
- Helps to switch between questions using buttons labelled 1, 2, 3, etc. under title 'Q.no.' which indicates question numbers.
- On question button click, question id along with its timestamp is asynchronously stored in the database table as it will be required for the 'PARAM' algorithm. For asynchronous database interaction AJAX calls are made.
- Next to the question buttons are the level indicators. They indicate the current state of the question. The full form of the NV, NA, NS, SP, and SS are also given at the bottom in the GUI i.e. Not Visited, Not Answered, Not Sure, Select and Proceed and Select and Save respectively.
- Initially all the questions are not visited, therefore NV is highlighted for all the questions.
- As soon as the question button is clicked it turns Green in colour and its level indicator gets changed to NA i.e. Not Answered.

2) Multiple Choice Question (MCQ):

- A set of questions are selected randomly from the database of question based on the specification from the teacher/corporate trainer.
- The same set of selected questions is asked to all the students but the order of question is changed. This reduces copy cases.
- On clicking the Question number button under Question Panel, MCQ appears on the right side with the marks allocated for it.
- Along with one of the four options, selection of one of the three levels is compulsory; else selected option won't be considered for evaluation and Question Panel will indicate it as not answered.
- At a time only one question appears on the screen which further reduces the chance of same question attempt at same time by different students.
- As soon as one of the three level buttons is clicked along with one of the answer, it is also reflected in the Question Panel and the question id along with the

answer-level pair is stored asynchronously in database table. • These levels provide the surety and confidence information for the answer selected.

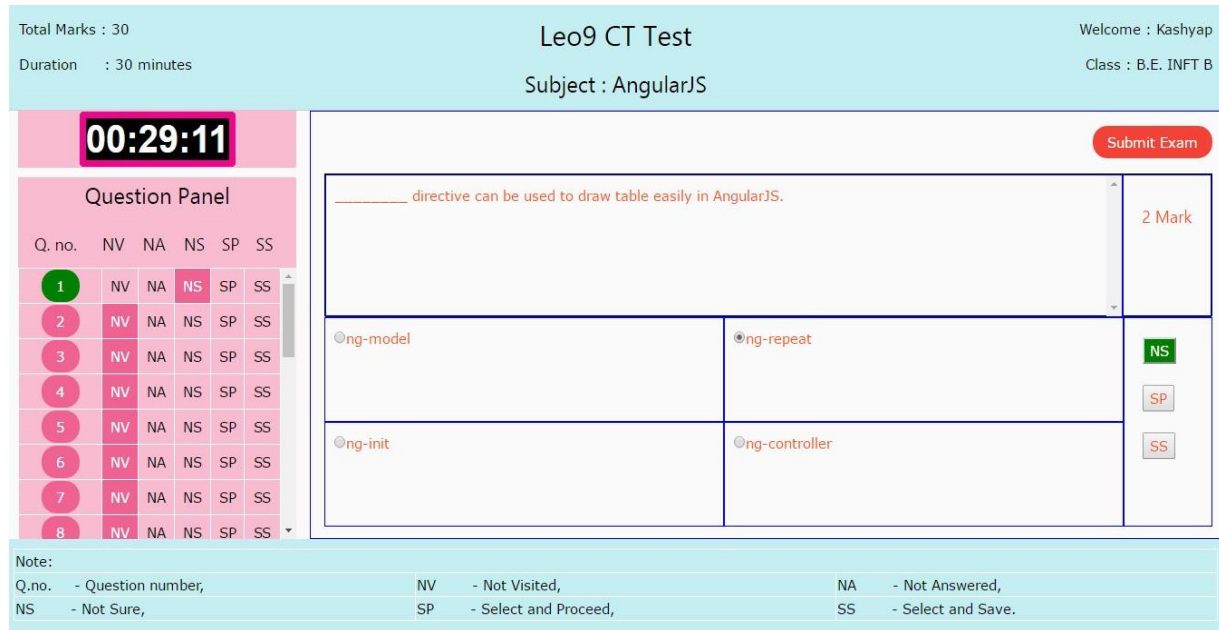


Fig. 2. GUI of Customized Online Examination System

3) Significance of the three levels[3]:

- NS (Not Sure): Selecting this level result in no loss of marks if the answer selected is incorrect, but will fetch $+0.25 * \text{Marks}$ allocated to the question if answer is correct. Answer and level is allowed to change.
- SP (Select and Proceed): This level result in $-0.25 * \text{Marks}$ for incorrect answering and $+0.75 * \text{Marks}$ for correct answering. Answer and level changing is allowed even with this level.
- SS (Select and Save): This level result in $-0.33 * \text{Marks}$ if the answer is incorrect and full marks for correct answer. Selecting this level locks the answer and the levels such that it can't be changed.

4) Exam Termination:

There are two ways of exam termination.

- Clicking on the Submit Exam tab present above the MCQ question. This way of termination indicates that the exam was terminated before time-up.
- When the time in the Countdown timer located above Question Panel reaches to 00:00:00. This way of termination indicates the time was up.

B. PARAM (Performing Assessment using Rule base reasoning and Machine Learning)

- For each question, for every student/trainee: option list, level list, no_of_visits (obtained from the count of timestamps stored for the question, for a particular student/trainee), static threshold (t_{min}) i.e. the minimum time required to answer a particular question which is specified by teacher while feeding question to the database, total time (T) to answer the question

(calculated as explained in [3]) are provided as an input to 'PARAM' algorithm [3].

- Using this input values, derived threshold interval $[t_d^-, t_d^+]$ calculated as explained in [3].
- Parameter 'k' i.e. number of times the option selection is changed is obtained from the count of option selection done for a particular question.
- The above inputs along with the $[t_d^-, t_d^+]$, k are provided as input to the Rule base defined in [3] for each question, for every student/trainee.
- The output is stored in the separate table in the database.

C. Custom Reports

Based on the inference obtained from the rule base and other data in the database, custom reports are generated. Custom reports provide the true state of understanding of the learners at different level of abstraction. For representing statistical diagrams in custom reports, 'Google charts' are used. The assessment of the answer to the particular question, by the student/trainee can be classified into eight categories namely, SS_True, SP_True, NS_True, SS_False, SP_False, NS_False, NA, NV. Here, SS_True means for a particular question student/trainee have selected level 'SS' along with the answer and the answer was 'True' i.e. correct. The other categories like SP_True, NS_True, SS_False, SP_False, NS_False also follows the same meaning convention and NA indicates that the question was not answered and NV indicates the question was not visited.

Custom reports that generated are broadly classified as Class level reports and Individual level reports as shown in Fig. 3.

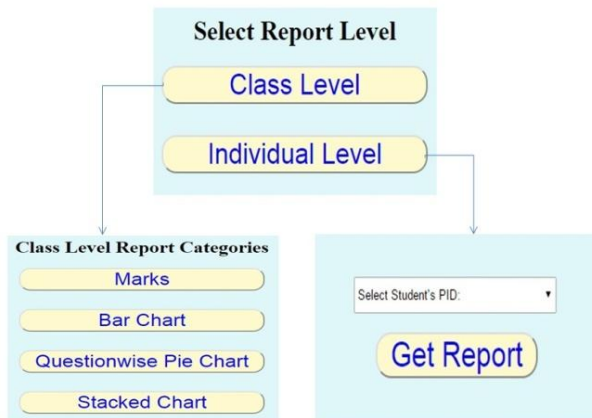


Fig. 3 Reports Classification

1) Class level Reports:

The various types of reports generated under class level reports provides the higher level view of understanding of students'/trainees', for all the concepts of which questions are asked in the customized online examination.

- **Marks:** This category gives the marks obtained by all the students, the student who scored highest, the student who scored lowest, average of marks obtained by all the students and count of the students who obtained marks in the specified range defined using two pointer slider.
- **Bar Chart:** The X-axis of the Bar chart represents number of students who appeared for the exam and its Y-axis represents the Questions. For each question on the Y-axis eight bars are drawn indicating the number of students who falls under the categories discussed above. Hovering effect over the bars provides the information such as question number, category of bar, student count for that category. The bar chart thus gives the count of students for all the questions falling in above eight categories.
- **Question wise Pie Chart:** This category provides the question level statistics using a 3D pie chart with hovering effect. The pies represent the categories discussed above for a particular question. On hovering the pie, we get category name, students in terms of number and percentage who fall in that category. Below the pie chart for the question, category wise name of the students along with the number of visits they made to the question is displayed. This gives the direct information of the students to whom the concept needs to be taught again.
- **Stacked Chart:** The category provides information similar to bar charts i.e. question number, student count and category. The difference is in the representation. Stacked chart are generated in terms of number of students and in terms of percentage of students. A single bar for each question is sub divided into eight categories; each when hovered provides the above information.

A colour convention is followed in bar chart and stacked charts such that shades of green represent correct answer

and shades of red represent incorrect answer, not answered and not visited. Shades of red and the lighter shades of green represent the students who require the concept to be discussed again.

2) Individual level Reports:

For each student, a micro-level analysis is provided in individual level reports. To access the individual level report of the student, select the PID of the student and click 'Get Report'. The report provides, for each question, the question asked, number of visits made to the question, list of options along with the corresponding level selected and changed for each question, correct answer, evaluation, marks obtained for the question and the realization (inference obtained from rule base) of true state of student's/trainee's understanding. Total marks are also displayed. Below all these details, a pie chart is displayed that provides the statistics of the assessment done for the final answer and the corresponding level selected for each question.

D. Implementation Details

For implementing the Graphical User Interface (GUI) HTML5, CSS was used. PHP was used for server-side scripting, whereas for client-side scripting Javascript and jQuery was used. For asynchronous interaction with the database jQuery AJAX was used. MySQL was used for implementing the database and its features like stored procedures and stored functions were used for implementing 'PARAM' algorithm [3], including its steps like calculating the total time (T) taken by student to attempt the question, calculating the value of $[t_d^-, t_d^+]$, implementing the Rule base. As a localhost during the development, XAMPP server was used. Netbeans was used as IDE (Integrated Development Environment). For validating and making the system live on the web Godaddy Hosting service was used. The system was tested for browser support on the browsers like Google Chrome, Mozilla Firefox, Internet Explorer, Opera and Vivaldi.

IV. EXPERIMENTAL SETUP AND REPORTS ANALYSIS

Exam was conducted using the above customized online examination system at Leo9 studio (www.leo9studio.com) during their corporate training. Leo9 studio is a medium size multinational company providing services like UI-UX development, web and technology, mobile app development, branding in several domains like automobiles, e-commerce, energy, healthcare, hospitality, travel, movies, real-estate and many more. The specifications of the exam are shown in table 1.

TABLE I EXAM SPECIFICATION

Specification Name	Value
Subject	AngularJS
Title	Leo9 CT Test
Exam Duration	30 minutes

Total Marks	30
Number of Trainees (Students)	24 (1 trainee was absent, therefore 23)

obtain in the exam, in this case 30. Below the student count is the marks obtained by all the students of the class along with their name and PID number.

The questions are classified as 1 mark and 2 mark MCQ's. Corporate trainer (teacher) fed questions of total 65 marks in the table of database of which 37 questions were of 1 mark and 14 questions were of 2 marks spanning across various topics under AngularJS subject. Based on the specification (20 questions of 1 mark and 5 questions of 2 marks totalling to 25 questions of 30 marks) provided by corporate trainer questions were randomly selected from the question table of the database. This same set of selected questions were asked to all the trainees (students) but the order of the questions was shuffled using random function to reduce the chances of same question attempt at the same time by different trainees, thereby preventing copying.

The following section provides the glimpses of the custom reports generated along with its analysis obtained after conducting the above test.

A. Class level reports

1) Marks:

The Fig. 4 is the screenshot of the report under Marks tab. It shows that the Harsh (trainee) scored highest marks i.e. 22.5 and Yash (trainee) scored lowest marks i.e. 7.09. The average of marks obtained by trainees is 15.659. The two pointer slider of total marks obtained by the trainees' when set with lower limit value as 15 and upper limit value as 25 gave the student (trainee) count as 14. It means 14 trainees got the total marks between 15 and 25. Similarly, slider can be adjusted to different marks ranges. The lowest possible value a pointer can have is the marks of the trainee (student) that is lowest, in this case 7.09 and the upper limit is the maximum marks a trainee (student) can

2) Stacked Chart:

The bar chart and the stacked chart provide same information with different way of representation. The stacked chart can also be obtained in terms of percentage of students instead of number of students. The stacked chart in terms of Number of students is shown in Fig. 5. Along the Y-axis are the 'Questions' asked in exam and along the X-axis is the 'Number of students (trainees)'. As discussed above there were 25 questions asked in exam and there were 24 students expected to appear the exam of which 23 actually appeared and one was absent. The legend provided at the top of Fig. 5 specifies the meaning of various colours in stacked chart. The shades of green specify the questions correctly answered whereas, the shades of red specify the questions wrongly answered, not answered and not visited. If we observe the Fig. 5 clearly Question 5, 10, 12, 14 have the shades of red dominating. At the higher level of abstraction, it indicates that majority of the students were not able to answer these questions correctly as expected. It may be because of some confusion with the concepts or concept not understood at all. When mouse pointer was hovered over red colour in Question 5, it tells there were 16 students who had selected SS level for their selected answer and have got it evaluated as incorrect. To further identify these 16 students who got SS_False, as well as students who got other seven categories for question 5, 'Question wise Pie Chart for question 5 will help. The questions in which shades of red are dominating should be discussed again at the class level whereas the questions in which the shades of red are in minority should be discussed at group level or at individual level with the students, by identifying the students using Questionwise Pie Chart as discussed in next section.

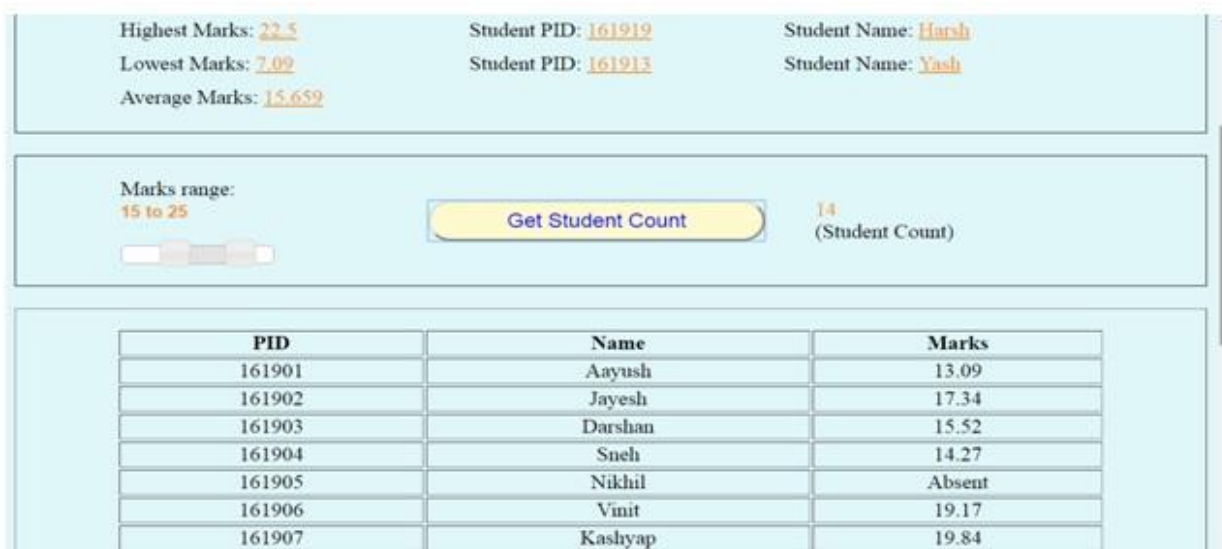


Fig. 4. Class Level Marks Report

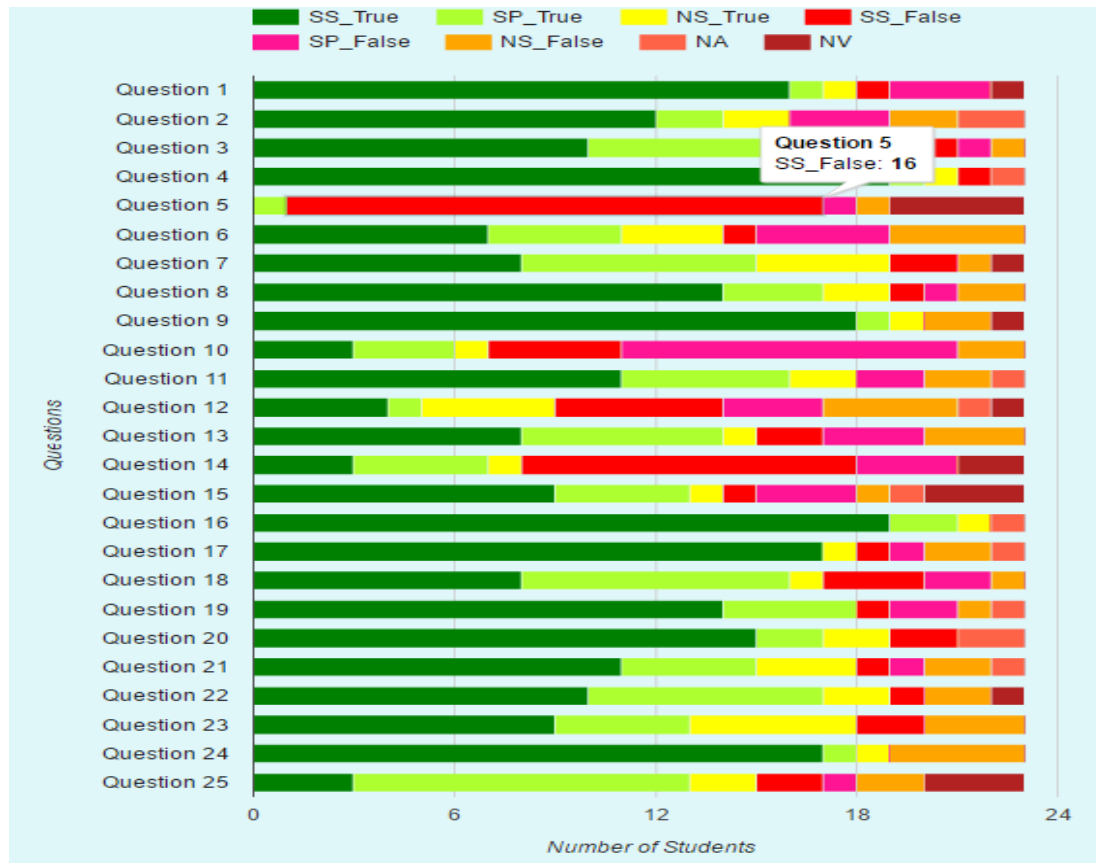


Fig. 5. Class Level Stacked Chart Report

3) Questionwise Pie Chart:

Fig. 6 shows 'Pie Chart' for 'Question 5', representing the statistics of answer (given by student/trainee) assessment which is categorized into one of the eight categories discussed above. Below the Pie chart details of the students classified into the various categories represented by pie is given, as shown in Fig. 7.

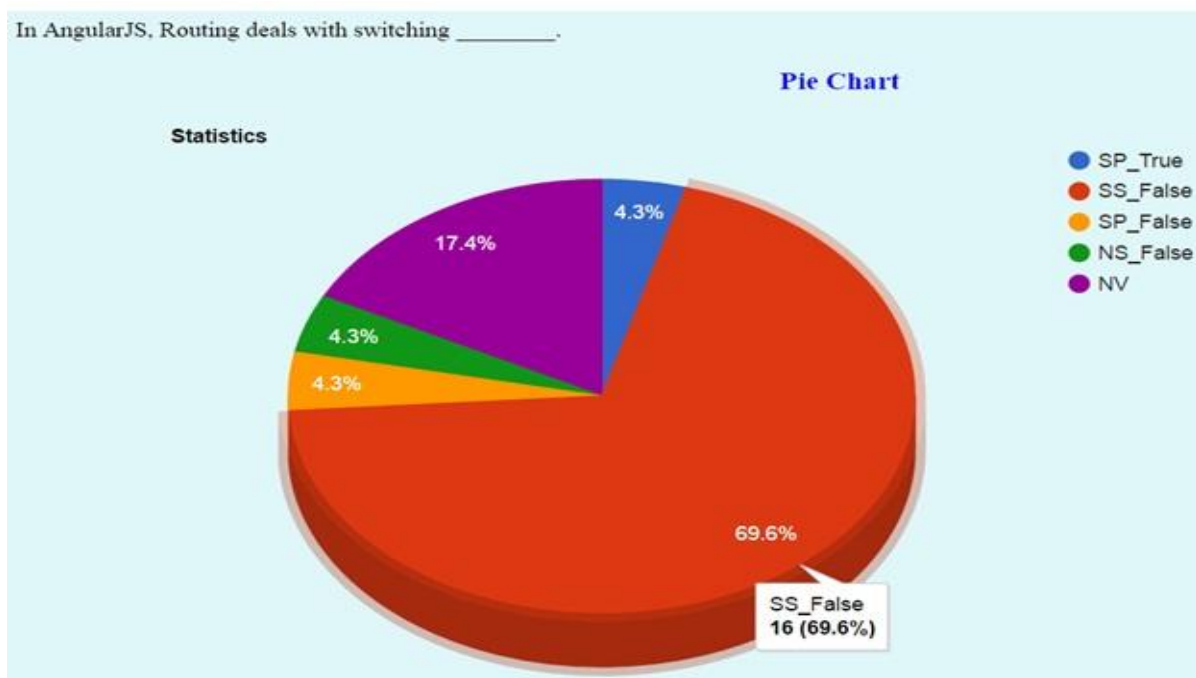


Fig. 6. Pie chart diagram of Question Number 5

SS_False

PID	Name	No. Of Visits
161901	Aayush	2
161903	Darshan	1
161904	Sneh	1
161906	Vinit	1
161908	Hardik	1
161909	Kushal	1
161912	Jay	1
161914	Bhavik	1
161915	Abhishek	1
161916	Jignesh	1
161917	Atmiya	2
161918	Pratik	1
161920	Hitesh	1
161921	Viral	1
161923	Mahesh	1
161924	Nirmal	1

SP_False

PID	Name	No. Of Visits
161907	Kashvao	1

Fig. 7. Students' detail having final answer for Question 5 evaluated as SS_False

On hovering the pie which is red in colour representing SS_False evaluation for question 5, it shows the trainee (student) count in terms of number for the category, which is 16 and also the trainee (student) count in terms of percentage which is 69.6%. The details of these 16 trainees are shown in Fig. 7 including their PID number, name and number of times they visited the question. As shown on the right side of the Fig. 7 which is a screenshot, there is a scroll bar, moving which details of trainees in other categories can be viewed. Once the trainees' details are obtained, in depth analysis of their competence/confusion/understanding can be obtained by viewing their Individual Reports.

B. Individual Level Reports

The glimpse of individual report of trainee having PID number 161921 is shown in Fig. 8. The report is in tabular format with a 'Pie chart' at the bottom. From the report Corporate Trainer (Teacher) gets the realization that the trainee (student), even though in question number 1 and 2, student got the answer evaluated as correct but was confused with other options. The 'Option-Level' list column provides the information of the answers selected and changed, which helps the trainer understand the confusion was with which options. The 'Realization' column gives the inference based on the Rule base discussed in [3] about the true state of student's understanding for each question, for every student. For question number 5, which was taken into consideration for analysis, the student had selected 'Controllers' as the answer with level 'SS', but the correct answer was 'Views' as shown under 'Correct Answer' column. The 'Realization' column thus infers that the student's answer was 'Wrong', Overconfident, because the student selected 'SS' level and it infers that the student have misunderstood the concept. For evaluating the competence in terms of

marks the student is given -0.33 marks for question number 5 as per the significance described above of 'SS' level. The total marks the student obtained is shown at the end of the table. This student obtained 18.18 marks out of 30. At the bottom of the individual level report a 'Pie chart' is shown which provides the statistics of the assessment of answers given by the student to the 25 questions asked in exam. The pies in the pie chart represent the eight categories discussed above but at individual level for all questions (25 questions) asked. The pie chart in Fig. 8 shows that among the 25 questions student having PID 161921 have got 14 questions (56%) evaluated as true/correct with level 'SS' which indicates high confidence for the answer. 16% of the questions i.e. 4 questions evaluated as true/correct with level 'SP' which indicates low confidence for the answer. 4% of questions i.e. 1 question evaluated as true/correct with 'NS' level which indicates very low confidence or concept not understood and got correct by luck. 16% of questions i.e. 4 questions evaluated as false/incorrect with level 'SS' which indicates student overconfident/misunderstood the concept or solved incorrectly. 4% of questions i.e. 1 question evaluated as false/incorrect with level 'SP' which indicates student was having low confidence for the answer due to either some confusion or misunderstanding with the concept and remaining 4% of questions i.e. 1 question with level 'NS' is evaluated as false/incorrect which indicates trainee did not understood the concept.

The corporate trainer when interacted with trainees' based on the these reports, it was found that the report provides true positive results for recognizing the true state of students' understanding. The interaction with the student based on these reports at the class level, group level and at individual level helped corporate trainer get aware of unrealised and not raised doubts/confusion of the trainees.

PID : 161921
Name : Viral

Serial No.	Question	No. of Visits	Option-Level	Correct Answer	Evaluation	Marks Obtained	Realization									
1	AngularJS is a _____ library.	3	<table border="1"> <tr><td>PHP</td><td>-</td><td>NS</td></tr> <tr><td>PHP</td><td>-</td><td>SP</td></tr> <tr><td>Javascript</td><td>-</td><td>SS</td></tr> </table>	PHP	-	NS	PHP	-	SP	Javascript	-	SS	Javascript		1	Correct answer with confidence, but had confusion with other option
PHP	-	NS														
PHP	-	SP														
Javascript	-	SS														
2	Built-In service to make XMLHttpRequest is _____.	2	<table border="1"> <tr><td>\$xssl</td><td>-</td><td>SP</td></tr> <tr><td>\$http</td><td>-</td><td>SS</td></tr> </table>	\$xssl	-	SP	\$http	-	SS	\$http		1	Correct answer with confidence, but had confusion with other option			
\$xssl	-	SP														
\$http	-	SS														
3	Directives are markers on _____.	1	<table border="1"> <tr><td>Document Object Model</td><td>-</td><td>SS</td></tr> </table>	Document Object Model	-	SS	Document Object Model		1	Correctly answered with confidence in normal amount of time, perfect understanding						
Document Object Model	-	SS														
4	Directives are used to create custom _____.	1	<table border="1"> <tr><td>HTML tags</td><td>-</td><td>SS</td></tr> </table>	HTML tags	-	SS	HTML tags		1	Correctly answered with confidence in normal amount of time, perfect understanding						
HTML tags	-	SS														
5	In AngularJS, Routing deals with switching _____.	1	<table border="1"> <tr><td>Controllers</td><td>-</td><td>SS</td></tr> </table>	Controllers	-	SS	Views		-0.33	Wrong, overconfident, concept misunderstood/solved incorrectly						
Controllers	-	SS														

24	_____ directive creates a placeholder where corresponding view can be placed based on configuration.	1	<table border="1"> <tr><td>ng-view</td><td>-</td><td>SS</td></tr> </table>	ng-view	-	SS	ng-view		1	Correctly answered with confidence in normal amount of time, perfect understanding
ng-view	-	SS								
25	_____ is a key service which sets the configuration of URLs	1	<table border="1"> <tr><td>\$routeProvider</td><td>-</td><td>SP</td></tr> </table>	\$routeProvider	-	SP	\$routeProvider		1.5	Correct, took normal amount of time, low confidence for the answer
\$routeProvider	-	SP								
Total Marks Obtained						18.18				

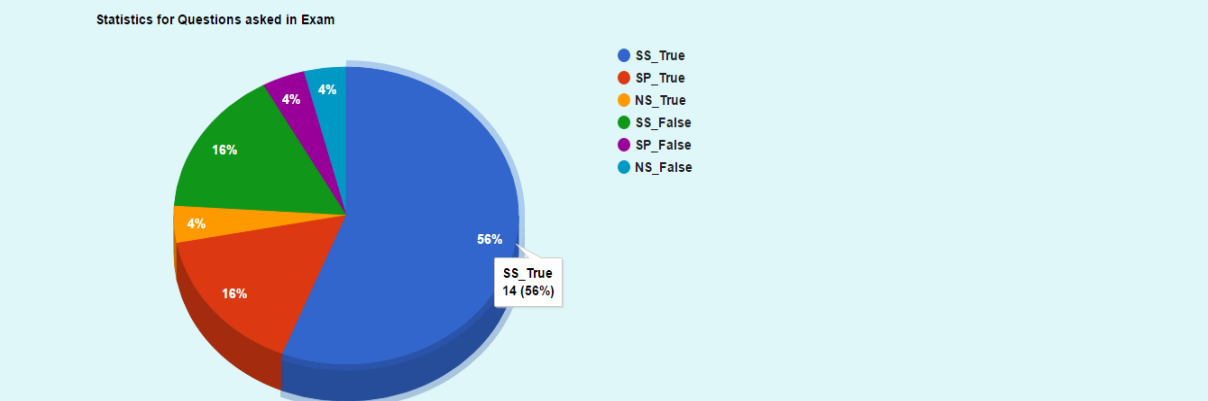


Fig. 8. Individual report of trainee with PID number 161921

V. CONCLUSION

The assessment obtained using the custom reports at the class level and the individual level helps the corporate trainer (teacher) to recognize from their side the doubts/confusion the students' have with the concepts they taught. It makes the teacher independent of relying on students' to raise their doubts/confusion by getting the awareness of their true understanding in the reports. While providing a novel approach to recognize students' difficulties with the concepts, the customized online exam system used in the proposed approach also provides the assessment of competence of the students'/trainees' in terms of marks that can be used for comparative gains.

VI. FUTURE SCOPE

In further iterations of development other features like module for management access to custom reports to get the true feedback of teaching quality can be added and the system can be converted from web application to mobile application to increase its usability.

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approach of recognizing true state of students' understanding.

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BIOGRAPHIES



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