

# Application of Edutainment Concepts and Tracking Emotions Based on Transient Emotion Peak in Online Education Systems

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**Abstract**—Edutainment concepts such as Game-based learning (GBL) and ‘gamification’, pave the way for students to learn by experience by going beyond the traditional teacher-centred learning environment concepts. This paper is an attempt to investigate the feasibility of implementing a virtual learning environment by using “Edutainment” concepts to teach Computer Science subjects to undergraduate students in the Sri Lankan context while finding the most effective way out of GBL and gamification approaches in teaching and facilitating an online test environment to have frequent formative assessments to self-evaluate themselves. The first goal was to identify this student cohort’s preferred way out of GBL and gamification in learning. In this study, a game and a similar gamification approach were designed to teach a subject. Next, a qualitative analysis was conducted by collecting students’ feedback on each approach and a quantitative analysis was done to compare the effectiveness of the two approaches based on answers given to a quiz based on that subject. Under the second goal, it was found that effective feedback should address the emotional level of the student too. Hence, this study proposed a systematic way to track the emotional changes based on the transient emotion peak. We conclude, that adult students mostly tend to grab the core concepts rather than playing sophisticated games and though the proposed emotion tracking algorithm the emotions can be tracked at a promising accuracy level. In future work, we suggest that it would be better to use the proposed time interval to track the concentration level based on corresponding facial features.

**Index Terms**—Constructive Feedback, Formative Feedback, Game-based Learning, Gamification, Stimulus Activity, Student Evaluation, Transient Emotion Peak Time

## I. INTRODUCTION

To give the students the ability to learn in a student-centered learning environment in addition to the traditional teacher-centered learning environment, “Edutainment” concepts can be used. When the students have an opportunity to have a student-centered learning environment, it leads them to have active learning which improves the thinking ability of the students [1], [2]. Now it has been realized that the usage

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of computer games for educational purposes offers a variety of opportunities to apply the knowledge within a virtual world, thus facilitating the learning process. That is because, rather than studying the theory and imagining what would happen, the students have the opportunity to make observations depending on the experiments in an imaginary world. The students can, for example, do virtual experiments to observe the reactions of chemicals, and by using haptic devices the students can feel the reactions of chemicals [3] so that they can learn the limitations of the particle movements. Hence, the students can acquire a vast store of knowledge which they are unable to access in the real world. Sometimes the students may have also the chance to develop their personality and communication skills by interacting with various types of people through online systems. One such innovative education paradigm is called “GBL” which helps students of various age levels to develop their learning process. No matter whether it is primary, secondary or higher education, we can apply this concept in any educational system to enhance the learning process. A gamified environment is a system which applies gaming rules to non-gaming environments. Here, the basic objective is to offer gamification elements and rewards (a badge, sticker or a star) to the students so that they can be motivated. For example, when a student has scored marks above a particular level, they may be given a sticker to indicate that they have been able to pass a particular level in a subject domain. There are various types of game-based learning approaches depending on factors such as age level and subject stream. Some of the subjects need a GBL approach irrespective of the age group and some need gamification approaches. Before introducing a student-centred learning approach in educational systems, there should be a proper analysis as to how this should be applied according to the subject and the age group or educational level. Hence, the first contribution of this study was finding out the most effective way out of ‘GBL’ and ‘gamification’ to introduce an “Edutainment” based course module to Computer Science undergraduate students.

The second intention was to give these students frequent formative assessments to evaluate themselves throughout a course module to improve their knowledge in a student-centred approach. Receiving frequent formative feedback in an education system improves the performance of the students at the end of summative evaluation [4]. It is shown that in



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student-centred learning environments, having self-correction frequent formative assessments can improve learning as well as the motivation of the students [30]. As evaluating multiple assessments throughout a course by a teacher is rather infeasible, it is better to have online tests with automatic feedback. In order to provide effective feedback, researchers have come up with a concept called “Intelligent Tutoring Systems (ITS)”. That means giving feedback to the students by taking into account various factors such as evaluating their performance and the approach that they have followed while solving a particular problem. This allows “Instructor immediacy” so that the students can feel a psychological closeness to the teachers [38]. First, we studied the way of forming effective feedback in a normal teaching environment and then checked the feasibility of adapting those concepts into an online environment. A feedback for a particular situation should at least consist of the following components according to Fisher et al. [5].

- Appreciation: expression of gratitude or approval of another’s effort. It is an expression of emotion, designed to meet an emotional need.
- Advice (or Coaching): suggestions about a particular behaviour that should be repeated or changed. It focuses on the performance.
- Evaluation: ranking the subject’s performance in relation to that of others or against an explicit or implicit set of standards.

Further, feedback can be generated according to three components (appreciation, advice and evaluation) while containing the properties as mentioned by Brophy [37]. Brophy [37] mentioned that formative feedback should be multidimensional, non-evaluative, supportive, timely, specific, credible, infrequent, and genuine.

By taking into consideration the properties mentioned above, it was decided that feedback can be easily generated at the end of an online test (timely, infrequent, genuine, credible) for each question (specific), based on the emotion at that time (supportive/ appreciation), based on the time taken to answer the question (non-evaluative/ advice) and correctness (evaluation). The correctness and the time taken to answer the question can be monitored through a programme easily. However, there should be a systematic way to track the emotions based on each question and then incorporate this into the feedback. Hence, the second part of this study gave a higher weight to trigger the emotion at an appropriate time while answering the questions at an online quiz.

## II. RELATED WORK

### A. GBL or gamification for undergraduate students

Currently, various types of online games exist such as action games, adventure and role-playing games, arcade games, strategy games, simulation games and driving games. It was found that playing games can be used not only for entertainment or to get rid of stress but also it can also be used to improve the analytical and thinking skills of the users. The education system can be divided into kindergarten, primary education,

secondary education and tertiary education (university and further education) in most of the countries [?]. We studied all the instances where game-based learning has been applied in each category mentioned above [7]–[12]. We analysed the gaming logic, Physics and gaming engines used in the above mentioned studies [13] and introduced a simple car game [14], [15] to the students to teach ‘Peterson algorithm’ which comes under Operating Systems course module. Based on that game, we were able to do a qualitative analysis to identify the students’ ideas towards a game. For that, a “Likert type” (rating scale) questionnaire was used.

In order to come to a conclusion as to which concept would be effective for this cohort of students (Computer Science undergraduates), we had to let the students to use both ‘GBL’ and ‘gamification’ modules. Though the gamification concept was initially introduced to improve marketing strategies [16], it is being now used in educational systems because it encourages and motivates students’ engagement in learning while allowing the teachers to achieve their objectives. A gamified environment is a system which applies gaming rules to non-gaming environments. Here the basic objective is to offer gamified elements/rewards (a badge, sticker or a star) to the students so that they can be motivated. When applying gamification to a particular education system, there is a five-step process that has to be applied [17] and it is shown in Figure 1.



Fig. 1. Five-step process in applying gamification

The first step involves, determining the target group. This can be decided by paying attention to the age group, learning abilities and background knowledge while the context can be determined by thinking of the group size, environment and time frame. After setting the learning objectives, the goals have to be set as to how the knowledge should be expanded step by step. The next step is to identify the resources and there the following questions must be answered [17].

- Is there a possibility to track the students’ performance at each stage of the learning process?
- What are the factors that could be used to measure achievement at each stage (points, marks)?
- Have the gaming rules been implemented clearly?
- Does the system provide adequate feedback to students/teachers?

Finally, the gamification elements have to be applied to the learning program. Two types of elements have been defined for this purpose, i.e. self-elements and social-elements. Self-elements are included to indicate the student’s status through their achievements. The social-elements enable the students to compare themselves with others.

Gamification approach also tries to apply three major positive themes to learning environment as in GBL, i.e. engage-

ment and motivation, academic achievement and interaction and socialisation to gain more [18]. Zainuddi and et al., [18] emphasized that gamification can be made effective in learning by improving the above mentioned three factors. The first step of gamifying a course module is the understanding the target group which is a key factor which leads to implement an effective gamified module [18]. Further, it has to be mentioned here that, Landers et al., [19] mentioned that further studies should be carried out based on theoretical foundations of gamification in education.

Gamification is different from game-based learning because it does not allow the students to play video games directly, but it includes most of the gaming elements such as narrative, immediate feedback, fun with challenges, mastery levels, progress indicators (through points/badges/leaderboards, also called PBLs), social connection and player control.

By going through the gamification approaches in university education [17], [20], [21], it could be seen that this approach has also paved the way to analyse the basic design elements which facilitate GBL approach, i.e. cognitive, social/cultural as well as behavioural engagement of the students.

### B. Receiving feedback through online systems

Performance evaluation systems were analysed in both traditional education systems and online education systems [22], [23] and the drawn conclusions are as follows.

- The best way to monitor the students' actual emotions/behaviour is by monitoring them without letting them know that they are being monitored and setting up a normal education environment.
- Pass the tracked behaviour of the students to the teacher so that he/she can get an idea whether the student has approached the correct way to solve a problem
- Use some tools to modify the learning materials in effective way according to the behavior of the students
- Give the feedback to the individuals according to their approach of problem solving and by analyzing their emotions which are identified through analyzing the facial expressions

As mentioned in the 'Introduction' section, the second main goal of this study was to analyse the emotions of the students' while they answer the questions at an online test. That is because, when it comes to 'appreciation' (one of the three main features of an effective feedback), the effort that a student puts in answering/ learning reflects from their emotions. Hence according to the conclusions drawn in [22], it was decided that one of the most feasible and convenient ways of analysing emotions was through facial expressions in an online system. However, there was a requirement to have a systematic way to track the emotions based on each question, while the students were engaged in answering. As the intention of this study was to analyze facial expressions through a photograph, it was decided to use an application that recognizes emotions through facial expressions. There are Application Programming Interfaces (API) and Software Development Kits (SDK) that can be used for this purpose.

Under this second section, two comparisons were done and one was to finalize the basic emotions that could be identified through the facial expressions [23] and the second comparison was to finalize an API that could be used in emotion recognition as shown in the Table I.

Features	Kairos	Amazon Rekognition	Google	MS Emotion API	IBM	Affectiva	OpenCV
Face Detection	C	C	C	C	C	C	C
Face Recognition	C	C	x	C	x	x	x
Emotional Depth	C	C	C	C	x	C	x
Emotions Present	C	C	x	C	C	C	x
Age & Gender	C	C	C	C	C	C	C
Multi-face Tracking	C	C	C	C	C	C	C
SDK	C	x	x	x	x	C	C
API	C	C	C	C	C	C	x
Ethnicity	C	x	x	x	x	x	x
Number of Emotions identified	6	7	4	8	-	5	-
	Anger	Anger	Anger	Anger	Anger	Anger	
		Confuse		Contempt			
		Disgust		Disgust		Disgust	
		Fear		Fear			
	Joy	Happy	Joy	Happy		Happy/joy	
		Calm		Neutral			
	Sad	Sad	Sorrow	Sad		Sad	
	Surprise	Surprise	Surprise	Surprise		Surprise	
		Unknown		No attention		eye widen	

TABLE  
FACE RECOGNITION AND EMOTION RECOGNITION APPLICATIONS

After doing another comparison on 'Amazon Rekognition'<sup>1</sup> and 'Microsoft Emotion API'<sup>2</sup> based on image size limit, performance testing and video tagging, it was decided to select Microsoft Emotion API. Moreover, it was able to categorize facial expressions up to eight emotions. The eight emotions are anger, contempt, disgust, fear, happiness, neutral, sadness and surprise.

The duration for each emotion that long last on a face cannot be always a constant value and it might vary depending on each emotion and the situation. There seems to be no strong correlation between the transient emotions strength and its duration [25]. Hence, tracking the emotion by a camera would be a complicated task to check whether the transient emotion can be seen when answering a question with respect to this scenario (online test).

1) *Transient emotion peak*: It was found that an expression can be seen on a face after an occurrence of a stimulus after 2 seconds, but within the first 4 seconds [26]. Sometimes facial expressions can be seen within 100 milliseconds based on startling occurrences, but they were not recognized as emotions [26]. The other point was, that for a natural spontaneous stimulus occurrence, emotions may last for 0.5 seconds to 4 seconds on the face [27].

In this situation, the stimulus occurrences were defined as the reading of the question and the selecting of an answer. Hence the expressions were seen when reading the question for the first time or submitting the answer to the system [23].

<sup>1</sup><https://aws.amazon.com/rekognition/>

<sup>2</sup>Microsoft, E., API (2017). "Emotion API." Microsoft Azure. Retrieved February 20, 2016, from <https://azure.microsoft.com/en-us/services/cognitive-services/emotion/>

C. Qualitative and quantitative analysis in GBL

GBL is a multidimensional field, and using both qualitative and quantitative methods allows researchers to gain a comprehensive understanding of the educational gaming experience [32]–[34]. Qualitative analysis can capture in-depth insights into the learning process, while quantitative analysis can provide statistical data for broader trends [35], [36]. Hence, both types of analyses were carried out in this study as other studies have followed both analysis mechanisms [32]–[34].

III. METHODOLOGY

In the first section, the plan was to select the most suitable concept out of the two concepts, “GBL” and “Gamification”. In order to achieve this, a gamification module and a GBL module were implemented/used for the same course. By doing both qualitative and quantitative analysis we compared the preference of the students and observed the most effective way to deliver a course for the students [28].

In the second section, tracking the students’ emotions through their facial expressions was done. Through that effective feedback were generated to the user. To achieve this purpose a methodology was developed to track the emotion of the student who was engaged in an online test. After that, the emotion results were evaluated statistically with the corresponding data set. The overall design architecture is depicted in Figure 2.

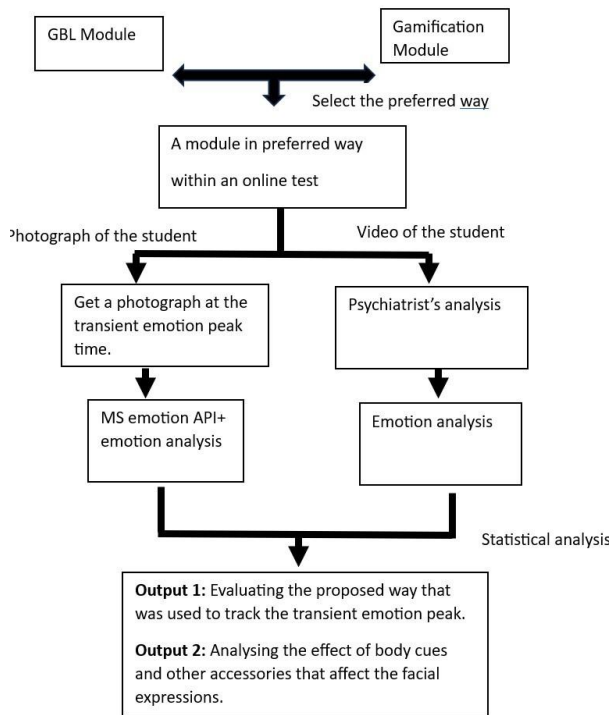


Fig. 2. Overall system architecture

A. Analysing student preference

To compare the preferences of the students and the effectiveness of teaching with GBL approach vs. gamification

approach, there should be a gaming module as well as a gamification module to teach the same subject to the students. For that, a subject had to be selected so that every participant with a similar background knowledge were going to learn the subject through this module, because it was decided to carry out the comparison of effectiveness of these approaches by letting the students to take part in an online test. This was accomplished by doing a quantitative analysis by comparing students’ marks as well as the time taken to finish the tests. Hence, a background analysis of the participants had to be conducted. The participants were selected from the University of Colombo School of Computing (UCSC). It was found that that specific cohort of the students had not had any experiences with algorithms in the previous semesters and they had not had any computer algorithms-related subjects prior to that. Hence, it was decided to use a GBL and a gamified approach to teach some algorithms that these students had not learned in their first year. A group of 60 students who scored a grade higher than an “A” for the Mathematics for Computing course (1st-year 2nd-semester subject) was selected and recruited for the study so that it was possible to make the assumption that all the students were in the same level of knowledge.

The intention here was to get to know what sort of learning materials were expected by tertiary students, i.e. whether their performance was more towards the gaming components or towards the gamified materials which let them grab the underlying theory at a glance without any unnecessary and sophisticated graphical images. As such, a simple freely available game which was developed by Roderick [29], was used to give the idea of some sorting algorithms under GBL approach and a gamified material which gave the knowledge on the same sorting algorithms.

The design and implementation of the gamified component are described in [28]. Both the game and the gamified component were used to teach ‘bubble’ and ‘bucket’ sort algorithms.

1) *Qualitative analysis:* The students were given a questionnaire to gather information about their own ideas concerning the two learning components. The students were given the opportunity to give their opinions on both gamification and GBL concepts.

By analyzing the information collected from the questionnaires, it was expected that the medium favorable to the students could be understood. The questionnaire consisted of “Likert type” questions and the answers were analyzed by using bar graphs.

2) *Quantitative analysis:* After recruiting the students for the study, they were divided into two groups (30 students per group) and each group was again divided into two subgroups as shown in Figure 3. Thus the four subgroups are listed below.

- Group I, Sub Group 1.1: were given the Gaming Component to learn Bucket Sort
- Group II, Sub Group 1.2: were given the gamified material to learn Bucket Sort
- Group III, Sub Group 2.1: were given the Gaming Component to learn Bubble Sort



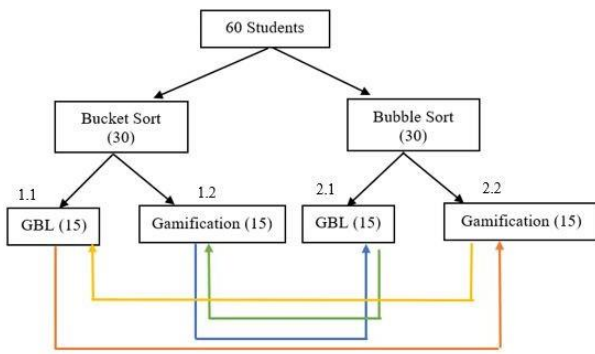


Fig. 3. Grouping of the students for the analysis

Group IV, Sub Group 2.2: were given the gamified material to learn Bubble Sort

At the end of the practice, the students were given a quiz and their performance (score and time) was analysed. The quiz consisted of five questions such that, three of them were based on the underlying theory while the remaining two questions were based on the code.

In addition to the score, the average time they spent learning the theory as well as the average time they took to finish the quiz were logged. After completing one iteration, the test was conducted in the other way around. That means, the bucket sort gamification module and the test were given to the sub-group 2.1 who have followed the bubble sort gaming component and bucket sort gaming module and the test was given to the sub-group 2.2 etc. as denoted in colour lines in Figure 3.

A paired t-test was used to determine which mechanism (GBL or gamification) helped the students to improve their performances. The null and alternative hypotheses used here were,

$H_0^1$  : There is no difference in marks obtained by following the gamified module or the GBL component.

$H_0^2$  : There is no difference in the time taken to finish the test by following the gamified module or the GBL component. (alternative hypotheses)

$H_1^1$  : There is a difference in marks obtained by following the gamified module or the gbl component.

$H_1^2$  : There is a difference in the time taken to finish the test by following the gamified module or the GBL component.

The assumption that was made here was the changes from bucket sort to bubble sort or vice versa have no effect on learning the other algorithm.

### B. Automatic Emotion Tracking Based on Facial Expressions

1) *Transient Emotion Tracker*: In order to collect data for the analysis, an online quiz was implemented. This was a website implemented by using ASP.NET which allowed the students to complete an online test with all the basic requirements. The site was hosted in the Azure cloud on a virtual machine and the question database was created by using SQL server. While the student was answering the questions,

a series of photographs were captured by the webcam, and they were sent to Microsoft (MS) Emotion API (Face API) to analyze the emotions. Before starting to answer the questions, the web browser should allow the webcam of the computer to be used. If the browser was not given permission to access the webcam, the emotions would not be recognized as there was no way to capture the photographs. For this study, 33 students took part and they were also selected from the same level of knowledge from the same institute.

Emotional changes can be triggered after a stimulus action and in this scenario that could be reading the question and submitting the answer. During that period the photographs were captured from the webcam and they were sent to the Microsoft Emotion API. The proposed way of analyzing the emotion based on each question was the tracking of the transient emotion peak. In this situation, based on the time taken to read the question, the transient emotion peak time can vary. Hence, the question reading time was considered as the independent variable, while the transient emotion tracking time was taken as the dependent variable. Before setting up the times, the median times taken for the students to read each question were calculated by using 100 instances [23].

The transient emotion peak time was calculated according to the literature as follows. According to Ruiz and et al's research [26], changes in emotions should be seen after the occurrence of the stimulus between the 2<sup>nd</sup> - 4<sup>th</sup> second and an emotion can last for 0.5 - 4 seconds of a time period [27]. Hence, emotion should be seen at the 2.5<sup>th</sup> (2+0.5) second after the occurrence of a stimulus in the best case or in the worse- case, it should be seen at the 8<sup>th</sup> (4+4) second.

Since the emotional changes could be seen from 2.5<sup>th</sup> second- 8<sup>th</sup> second according to the literature, it seemed sufficient to capture the images after the 2<sup>nd</sup> second following the stimulus activity (the time when this activity occurred being taken as the average median time calculated above). However in order to check the reliability of this concept, the images were also taken before that for every 1.1 seconds 13 times.

2) *Selection of the Photograph Against the Changed Emotion*: Through the MS Emotion API, the output was given as a probability value against each and every emotion. Then by comparing all the values received from the API for the series of photographs, the most extreme value which was considered as the emotion was noted after the stimulus action.

In addition to the webcam, a video camera was used to record the behaviour of the students while they were answering the questions. This videotape was analyzed by a psychiatrist and for each student for each question, an emotion was decided by him (benchmark data set). The emotions that correspond to the images at the transient emotion peak were compared with the benchmark data. To check the suitability of using the proposed time interval, cross-validate the accuracy of identifying matching pairs of emotions (from the API and the psychiatrist) during the proposed time interval. For this, a confusion matrix was used.

### C. Generating an effective feedback

1) *Achieving Appreciation (Emotion Analysis)*: This was achieved by analyzing the emotion. Depending on each emotion, the emotion was categorised as positive, negative or neutral. The final feedback was generated in a meaningful way so that the student could be motivated through a comment.

2) *Achieving Coaching (Time analysis)*: At this point, the time taken to complete a question was analyzed and a comment was provided to rate the time elapsed. Once the whole class had finished the assessment, the times taken to attempt each, and every question could be analyzed, and each student's time could be compared with the minimum time and the average time taken by the students who have answered a particular question correctly. Then it was informed to the student later to get to know as to how they had been deviated from the best time and the average time as an encouragement to improve their speed.

3) *Achieving Evaluation (Based on Correctness)*: The next attempt was to give a comment on the performance and it was only based on the correctness of the answer.

To generate a proper feedback system, a hierarchy can be established with the help of a physiological expert. We can classify the emotions or concentration level into a higher level category like positive, negative and neutral and can combine the other two binary values along with it to synthesise feedback. For example, when the student is showing a positive emotion with a correct answer in less time (when a predicted average time is provided) we can encourage the student by giving feedback like this. Or else when the student is showing a negative emotion, with a correct answer taking a long time, we can say that he/she might be having a doubt even though the answer is correct.

## IV. RESULTS AND EVALUATION

### A. Comparison of the Game-Based Learning Approach with the Gamified Module

1) *Qualitative Analysis for GBL VS Gamified Module*: Based on the "Likert type" questionnaire we were able to get the participants' opinion on the willingness to play this game, applying gaming modules on other subjects, how the game motivated them to study the course, whether was it too sophisticated and whether this provided them an adequate knowledge. This section was able to conclude as the participants were interested in learning through game-based leaning, which were not biased towards a gender and without too sophisticated Graphical environment [28].

2) *Quantitative Analysis for GBL vs Gamified Module*: When checking the hypotheses, mentioned in section III-A2 it was noted that at 95% confidence interval and the  $p$  value for test marks was 0.000008 and the  $p$ -value for time spent by the students was 0.0000006. Hence, both the null hypotheses (there is no difference in the marks/time of the students who followed the GBL component or gamified component) were able to be rejected for both situations based on the results.

### B. Automatic Emotion Analyser Based on Facial Expressions

The first step was to find the value for the independent variable, i.e. the time taken to read a question. According to the data, the median average time taken to read a question was 8 seconds. Hence, the occurrence of stimulus must happen after this 8 seconds duration [23].

Even though it seemed it was sufficient to capture the images from the 8<sup>th</sup> second (to reading a question it takes 8 seconds) after reading the question, in order to check the reliability of this concept, the images were taken from the 5<sup>th</sup> second for every 1.1 seconds for 13 times. In the best case, the first emotion was expected to be triggered from the 6<sup>th</sup> image which was taken at the 10.5<sup>th</sup> second or else the emotion was expected to be tracked in one of the other images taken as the 7<sup>th</sup> - 11<sup>th</sup> photograph. A cross-validation analysis was conducted to check the reliability of the proposed time interval in tracking the emotion by generating a confusion matrix and the results obtained from the data are as shown below in Table II.

Within the expected time interval	Emotion Matching	
	YES	NO
YES	202	80
NO	14	34
Sensitivity	93.52%	
Specificity	70.83%	
Accuracy	71.52%	
Misclassification rate	28.48%	

TABLE II  
CONFUSION MATRIX FOR CROSS VALIDATION

Assuming that the emotion would be correctly predicted when the capturing time was in the defined interval, the above confusion matrix was filled. After analysing the whole data set, by using the cross-validation methodology, it can be claimed that if this methodology was used, it is capable of capturing the emotion with an accuracy of 71.52% and the sensitivity rate was 93.52% while the specificity rate was 70.83%. The sensitivity value implies that if the image (prominent emotion) was detected within the defined (proposed) time interval it is capable of capturing the correct emotion with an accuracy of 93.52%. The specificity value indicates that, when the image (prominent emotion) was detected out of the defined time period, there is a chance of 70.83% of having a misclassification [23].

The other interesting fact that was noted was that 18.18% of students (6 out of 33) did not show any noticeable facial expressions throughout the test, but some eyeball movements and staring at the screen for some time. Hence, even though it was found that this time duration can be used in tracking the appropriate emotion out of the series of emotions when analysing the videos, it was realized that it is better to analyse features such as eyeball tracking since that shows the concentration level of the student. Hence it can be said that this could be enhanced by analysing the concentration level as mentioned in [31] rather than focusing only on the emotions.

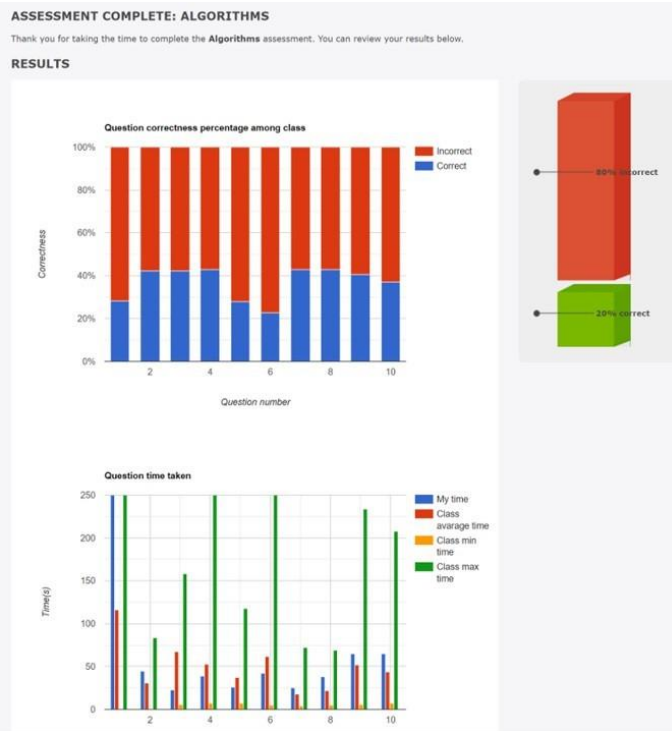


Fig. 4. Overall summary reports provided by the system after all the tests

### C. Online Feedback

Not only the students but also the module convener can see the correctness of the answers and the time taken to answer each question at the end of the test. Hence, the convener can have an overall idea as to how the students have performed in the assessment, like the percentage of answering a question correctly/incorrectly and the time taken by the students to answer each question. Figure 4 shows one such report that the module convener can receive, related to the correctness of the answers for each question for all the tests. The second graph shows the time spent on each question. It has three categories indicating the maximum time spent per question, the minimum time spent per question and the average time spent by the students per question.

An evaluation based on the report shown in Figure 4, was not conducted. These reports were generated for the module conveners so that they could get an idea about his/her class performance.

### D. Limitations

By analysing all the data, two main limitations were found in this study. The major limitation was, under emotion tracking, it was noted that there were (6 out of 33 = 18.18%) students who were not sensitive to facial expressions. It was noted that in this test environment students/ participants changed their eye movements indicating that they were concentrating more than showing changes in facial expressions. Most of the students had eyeball movements and they had been staring at the screen for some time when they were thinking about a

question. Hence it can be suggested that it would be better to have an enhanced way to track the facial features, for example using eyeball tracking to classify the effort of the students in answering the questions [31]. By comparing eyeball tracking, it seemed to classify students' moods easily whether the student is concentrating on the question or panicked or not during a test. However, there can be issues with the students who wear spectacles which will hinder the accuracy of eyeball tracking.

## V. CONCLUSION

The first conclusion derived as the gamification methodology seemed to be the most effective way of teaching algorithmic subjects in Computer Science concepts compared to GBL methodology. The effectiveness was able to analyse quantitatively from two perspectives i.e. by analysing the marks scored by the students after following each methodology and by analysing the time taken to answer the questions. In addition, based on the qualitative analysis data obtained from the 'likert' style questionnaires, another observation was able to made i.e. the majority of the students had selected learning through gamification as better when compared to the feedback provided towards GBL.

In order to have emotion tracking to analyse the effort put by the students while answering the questions, it is better to have an enhanced way to track the facial features, for example using eye movements to classify the effort of the students in answering the questions. Because there are students/humans who are not sensitive to facial expressions which is a limitation of this system. Hence, by comparing the iris and the eye movements, it seemed to classify students' mood easily whether the student is concentrating on the question or panicked or not during a test [31]. This is important because it was noted that a considerable number of students from this student cohort did not show any noticeable facial expression changes during the answering. Hence, it is suggested to use the transient emotion tracking time to track the specific changes of specific features that can be seen in an online education system rather than focusing on all the emotions. In Krithika et al's study [31], the eye movements and the head movements had been taken into account in analysing the concentration based on a video lecture. This would be a good way of analysing the emotional changes in an online education system. Krithika et al. [31], did not want to track the transient emotion peak from time to time since they had analysed the behaviour of the students at a lecture. Finally, it can be said that for an online test environment, it is better to have a transient emotion peak tracker to analyse the emotion type or concentration level (as positive/neutral/negative emotion) so that it can be used accordingly to form a suitable feedback. Because it is a technical and systematic way to track the transient emotion, it may give promising results.

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