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Development of the Low Cost Classroom Response System Using Test-Driven Development Approach and Analysis of the Adaptive Capability of Students Using Sequential Minimal Optimization Algorithm

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***Abstract*—This study discussed the development of the low cost student response using open-source frameworks which supports agile interaction design to address most of the Classroom Response System's problems such as the limited input capabilities as well as the cost of the infrastructure, subscription, and equipment which does not compromise the accuracy of the transfer of data. This development also benefit schools in some rural areas with limited access of Internet as well as the students with sufficient connection to the Internet to avoid high risk of distraction. To ensure the expected output of each unit, Test-Driven Development approach was performed in each unit feature in the backend development of the system. Further, surveys were conducted in grade 8 and grade 12 students to identify the percentage of students who are willing and able to adapt the CRS technology in their studies. Classification result shows that 73.5632 % answered that they are willing to adapt the CRS technology in their classroom. However, 47.83% in the remaining 26.44% have expertise and advanced knowledge in technology while the remaining 37% to the 26.44% are familiars and can only perform basic functionality of computer. Further, statistical result have identified the factors that correlate the student's preferences in using CRS.**

Keywords-Sequential minimal optimization, classroom response system, test-driven development

I. INTRODUCTION

Learning varies in different ways. There are students that can easily pick up lessons while some needs more attention. However, there are also lessons that can be easily grasped while there are lessons that need to be repeated. There are different levels of students that are needed to be understood in order to meet the needs of each student. The problem might be in the students or maybe the pedagogical approach of the teachers and the learning acceptance of the students. It has been noted that Classroom Response Systems (CRS) improved the learning outcome of the students [1] [2] [3].

However, most common major obstacles that can be faced in acquiring CRS is the availability of the infrastructure such as strong internet connection and available Wi-Fi connections as well as the cost of the commercial CRS including license, software, computer, and handheld devices which is very hard to obtain in areas with lack of financial support. Also, contrary to the limited access to the Internet, there is a high risk of distraction when a student is connected in the Internet [4].

The propose system to possibly address most of the CRS' problems faced has been developed using open-source frameworks which enabled the developers to produce low cost system to help address the academic performance issue in more granular approach and rapidly analyze the feedback of the students which does not compromise the connectivity and transferring of data. This software developed which supports agile design. Also, student's connectivity to transfer data does not need an Internet connection. Hence, this will be benefited in areas with limited access of internet as well as the areas with connection to the Internet to lessen the risk of the distraction. Further, to ensure the correctness of each unit, Test-Driven Development (TDD) approach was performed in this study. TDD ensures that anything that is not covered in the test is not going to be in the software [5].

II. REVIEW OF RELATED LITERATURES

A. Student Response System

The use of the technology allows teachers to give fresh approach to alleviate their teaching approach to students [2]. According to [3], the benefits of Student Response System can be applied in science, medicine, engineering, math, social science, psychology, marketing, and hospitality which is very essential that the students in this fields must appreciate their learning. Many studies proved that CRS improved the learning capability of students [1] [2] [3]. According to the analysis in the study entitled "Opinions on Classroom Response System by first-year engineering students" [6], CRS allow students to enhance their attention. In a study done by Murray, Rossiter, and Panoutsos [7] entitled "Promoting the use of clickers across a whole engineering faculty: how, why and is it worth it?" students from University of Sheffield in the United Kingdom were surveyed to evaluate the clicker technology. Result shows that most of the students think that they have given the confidence to answer correctly the questions. Another in the experiment conducted in the study of Gould [3] entitle "Potential Use of Classroom Response Systems (CRS, Clickers) in Foods, Nutrition, and Dietetics Higher Education", they surveyed students about how they feel regarding the use of the CRS technology paralleled to their

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performance outcome. Result shows that students rated the CRS technology high but the final score did not differ. However, it has been noted that students may help students to practice discussion even with challenging topics and made through higher level of thinking. It is truly that clicker technology is proven to be effective. According to [8], this is because it addresses the three primary educational principles, namely: question-based learning, active testing, and feedback.

B. Test – Driven Development

Testing is an integral part of the software development lifecycle [9]. According to [5], TDD works first in writing a test in a small bit of a functionality, and then write codes to make the test pass and create more tests and functionalities. It forces the programmers to think many aspects of the feature or story's scope. According to [10], TDD encouraged communication between customers and developers and it increases the programmers' confidence. Programmers write codes to make tests pass to show product owners that the delivered codes meet the expectation using languages that both users and programmers can easily understand [5]. However, TDD reduces the productivity of inexperienced programmers. On the other hand, when the painful learning curved has succeeded. There is exponentially higher probability that the customers have much more satisfaction. [5] [10]. Industry studies show that codes produced using TDD passed 18% to 50% than codes developed using the conventional programming [5].

III. METHODOLOGY

A. Development of the Software

Figure 1 shows the overall development of the backend and frontend of the proposed CRS. It describes the development of each module with tests on each of the features of the module in the backend.

1) Mobile – browser Application

The proposed system are developed in two framework categories: User Interface (UI) frameworks and Architectural framework. UI framework focuses on the UI widgets or components that are optimized for mobile platform [11]. UI framework supports self-contained component that manages its own view style and data logic as well as the managing of states which is constantly changing over time [11]. The second framework category provides structure to application in the form of design patterns. It supports one-way data flow that make state mutations predictable by imposing certain restrictions [11]. Hence, the backend development is structurally designed using NodeJS combined with React-Redux frameworks in Frontend. Further, MongoDB is used for database implementation.

Since the data returns in json file format, the database schema is designed according to the stakeholder's need. Hence, this addressed the possibility of CRS to include text options such as fill in the blank, and essay. The system also design comment option in each question. Hence, the view of the students would be acquired and not only limited on what the teachers induced.

The proposed CRS are deployed using Wi-Fi frequency to share data to and from the computer server. Students interact in the system by connecting to the same router the server has connected.

The actions performed of the user in the frontend module request to the backend module before it transmits data to or returns data from the database.

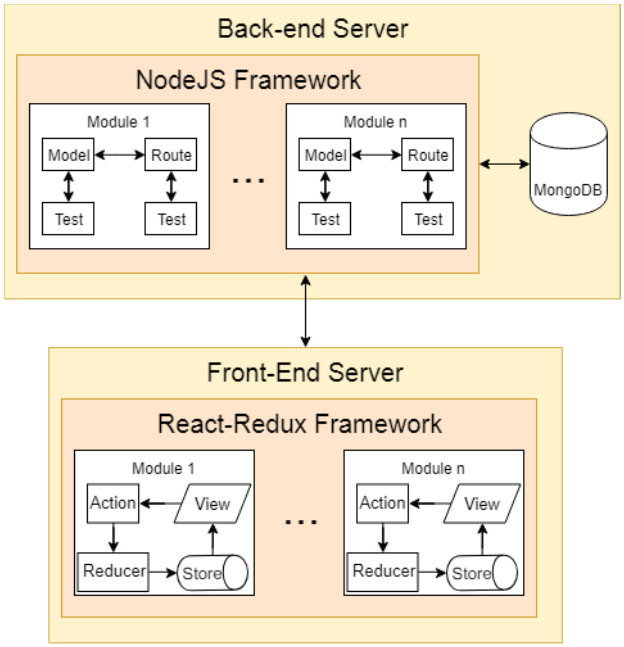

Figure 1. Software development methodology

2) Backend feature testing

Further, the tests performed in the backend used Mocha and Chai frameworks. The development experienced the painful learning curved during the first phase of building codes. Hence, somewhat reduced the production. However, when familiarity of the environment has passed, it minimizes the timeframe of the software testing and provides higher confidence that there are just very minimal to no bugs in the proposed software.

According to [12], TDD is described according to this formula:

$$TDD = Refactoring + TFD \quad (1)$$

wherein TDD is composed of refactoring and test First Development. It is when the developers create new feature in the system. The feature is then run into the system. If the feature failed to proceed to the test, the syntax should be refactored and change where the part is affected. And so, the syntax should proceed again to the TFD.

3) Sequential minimal optimization

This implementation of the analysis is adopted the John Platt's Sequential Minimal Optimization (SMO) [13] [14] which trains Support Vector Machine to solve the Quadratic Problem arrives using Support Vector Machine Algorithm. By finding the smallest possible sub-issue by identifying at least one of the dimensional function [15]. According to [13]

in his study entitles “Sequential Minimal Optimization: A Fast Algorithm for Training Support Vector Machines”, SVM performs well with linear SVMs, as well as with sparse and non-linear inputs.

This study implemented the Radial Basis Function (RBF) Kernel (equation 2) in training the Support Vector Machine (SVM) using SMO Algorithm.

$$K(x,y) = exp(-gamma * (x-y)\text{^}2) \quad (2)$$

According to Sangeetha and kalpana [16] in their study entitled ”Performance Evaluation of Kernels in Multiclass Support Vector Machines”, RBF also known as local kernel is transforming data into infinite dimensional Hilbert space. It performs better than linear and polynomial [16].

IV. Results and Discussion

A. Adaptive Capabilities of Students

Experimentation has been carried out using WEKA 3.8 data mining tool. Survey were implemented in order to identify how application of technology to the educational environment are necessity and the levels of the expertise of students. There are N=87 total number of participants composing of n=27 grade 8 students and n=60 Senior High School students took the survey. However, the limitation of this study is the small size because the total number of the students who participated. Table 1 shows the features of the survey and answers using Likert scale and Yes or No:

TABLE I. Technology Needs Analysis Survey Questionnaire

No.	*Feature*	*Answers*
Proficiency to technology		
1	Proficiency levels a user has in relation to computer technologies	1Unfamiliar, 2 Beginner, 3Average, 4Advanced, 5Expert
2	skill level using Android phone	Scale of 1 to 5
3	skill level using Android app	Scale of 1 to 5
4	skill level using Laptop	Scale of 1 to 5
5	skill level using Clicker	Scale of 1 to 5
Exposure to technology		
6	How frequent computer technology in learning and assessment activities	1Awareness, 2Learning, 3Familiarity, 4Adaptation,5 Creative 6Application
7	How frequent computer technologies are integrated into your assignments	1: Never 2: Practically Never 3: Once in a While 4: Fairly Often 5: Very Often 6: Almost Always
8	How frequent computer technologies are integrated into your seatwork	1: Never 2: Practically Never 3: Once in a While 4: Fairly Often 5: Very Often 6: Almost Always
9	How frequent computer technologies are integrated into your drills	1: Never 2: Practically Never 3: Once in a While 4: Fairly Often 5: Very Often 6: Almost Always
10	How frequent computer technologies are integrated into your end of topic exercises	1: Never 2: Practically Never 3: Once in a While 4: Fairly Often 5: Very Often 6: Almost Always
11	How frequent computer technologies are integrated into your self-test	1: Never 2: Practically Never 3: Once in a While 4: Fairly Often 5: Very Often 6: Almost Always
12	How frequent computer technologies are integrated into your quizzes	1: Never 2: Practically Never 3: Once in a While 4: Fairly Often 5: Very Often 6: Almost Always
13	How frequent computer technologies are integrated into your periodic exams	1: Never 2: Practically Never 3: Once in a While 4: Fairly Often 5: Very Often 6: Almost Always
14	Rate how much computers are unpredictable (crashed or did not work properly) be an obstacle for you.	1: Not an obstacle 2: Minor Obstacle 3: Major Obstacle
15	Rate how much late posting of test scores be an obstacle for you.	1: Not an obstacle 2: Minor Obstacle 3: Major Obstacle
16	Rate how much you have a hard time connecting with technology support be an obstacle for you.	1: Not an obstacle 2: Minor Obstacle 3: Major Obstacle
17	Rate how much Internet is too slow or drops connection be an obstacle for you.	1: Not an obstacle 2: Minor Obstacle 3: Major Obstacle
18	Rate how much low quality of connection in the area or building be an obstacle for you.	1: Not an obstacle 2: Minor Obstacle 3: Major Obstacle
Technology adoption		
19	Choose your willingness to use an in-classroom Android-based learning or assessment tool.	0:No 1:Yes

Survey result shows that 73.5632% of the respondents are willing to use the CRS in their study while the remaining 26.4368% choose not to use CRS. However, when identifying their capability and to adapt in the technology using the SMO classifier with features stated in Table 2, It has been noted that all students according to their capabilities are able to use the CRS technology.

On the other hand, 47.8261% of the 26.4368% students who are not willing to use the CRS have expertise and advance knowledge in technology while the remaining 37.826% are familiars and can only perform basic operations and functions in computer.

Table II shows the accuracy of the classification as well as the kernel evaluation.

TABLE II. Classification Result

Correctly Classified	Incorrectly Classified	RMSE	Kernel Evaluations
73.5632%	26.4368 %	0.5142	3493(81.668% cached)

Root Mean Square Error (RMSE) value shows that some data are somewhat far from the regression line. Further, Kernel evaluation which is 81.668 % cached used to analyze the data. According to [17], Kernel values must be stored or retrieved from a cached of often accessed values to speed up the classification. However, when using large dataset, the newly cached coefficients are deallocated whenever the memory allocated exceeds the maximum predefined allocation [17].

B. Correlation Measurement

On the other hand, a chi-square test is performed. Table 3 shows the result of chi-square and Cramer's Phi (φ) Coefficient also known as Cramer's V statistics [18]. Cramer's Phi (φ) Coefficient was used as a measure of parallelism to quantify the statistical correspondence between the preference of students to use CRS and other factors stated in Table I. Wherein $(df^*) = (row - 1)(column - 1)$in the contingency table stated in the study of Cohen, 1988 [19] and $\alpha = 0.05$.

TABLE III. CHI-SQUARE STATISTICS RESULT

Feature	Homogeneity assumption	Chi-square	df^*	p value	Phi and Cramer's V
Year level	0 cells	10.174	2	0.006	0.342
Q1	5 cells	9.795	4	0.044	0.336
Q2	4 cells	7.346	4	0.119	0.291
Q3	2 cells	3.647	3	0.302	0.205
Q4	5 cells	3.619	4	0.46	0.204
Q5	3 cells	11.052	4	0.026	0.356
Q6	3 cells	4.59	4	0.332	0.23
Q7	4 cells	4.542	4	0.338	0.228
Q8	4 cells	8.216	4	0.084	0.307
Q9	6 cells	7.533	5	0.184	0.294
Q10	5 cells	3.187	4	0.527	0.191
Q11	6 cells	12.445	5	0.029	0.38
Q12	5 cells	7.833	4	0.098	0.302
Q13	6 cells	9.265	5	0.099	0.328
Q14	2 cells	2.43	2	0.297	0.167
Q15	1 cell	3.17	2	0.205	0.191
Q16	2 cells	4.548	2	0.103	0.229
Q17	2 cells	3.917	2	0.141	0.212
Q18	2 cells	2.885	2	0.236	0.182

Table III shows the relation of Q19 in Table 1 against Q1 to Q18 items. Result shows items with association against Q19 according to Cohen's effect size [20] in Table 1 are:

- Year level with $X^2(df^* = 2, n = 87) = 10.174, p > 0.006, \varphi = 0.342)$ with medium effect between the Q19 and grade level,
- Proficiency level of students with regards to computer technologies with $X^2(df^* = 4, n = 87) = 9.795, p > .044, \varphi = 0.336)$ with medium effect between the Q19 and Q1,
- Skill level using Clicker with$X^2(df^* = 4, n = 87) = 11.052, p > 0.026, \varphi = 0.356$) with medium effect between the Q19 and Q5,
- Frequency use of computer technologies for self-test with $X^2(df^* = 6, n = 87) = 12.445, p > 0.029, \varphi = 0.38)$ with medium effect between the Q19 and Q11.

V. SUMMARY AND CONCLUSION

This paper discussed the development of a low cost CRS using TDD implementation that supports interactive design using the UI and structural frameworks which is a combination of NodeJS and React-Redux frameworks to support self-contained component and states that is constantly changing over time. Tests were implemented in the backend side of the software. Aside from developing a low cost CRS that is a major advantage for rapid feedback and analysis of the teachers to the lesson, one of the advantages of this study is the flexibility of the input capabilities since the schema returned in .json file. Hence, the database schema is designed according to the stakeholder's need including the Multiple Choice, Yes or No, Fill in the blank, and essay. Comment box is also included in each questions. Hence, providing more vivid interpretation in more granular way.

Further, survey performed the readily of the students in using CRS. This study performed SMO classification to classify percentage of students who are willing and able to adapt the technology according to the technology needs analysis. Result shows that 26.4368 % of the students are still want to use the traditional pedagogical approach. However, 39.13% of it have the advanced and expertise in technology while 60.87% are unfamiliar and know the basic functionality of computers.

On the other hand, a chi-square test is performed to identify if there is a relationship between the willingness of the students to use the CRS to the other factors indicated in Table 1. Result shows that the year level, proficiency level to the computer technologies, skills in using Clicker, and frequency use of computer technologies are correlated in e-learning preference with medium effect between against the willingness of students to use CRS. However, the limitation of this study is the small sample size due to limited number of students who participated.

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REFERENCES

[1] M. Ito and M. Miura, "Handiness of device-free response analyzer systems in the classroom," *International Conference on Knowledge*

Based and Intelligent Information and Engineering System, vol. 112, p. 1829–1834, 2017.

[2] H. Mohamed and M. Lamia, "Implementing flipped classroom that used an intelligent tutoring sytem into learning process," *Computers & Education,* pp. 62-76, 2018.

[3] S. M. Gould, "Potential Use of Classroom Response Systems (CRS, Clickers) in Foods, Nutrition, and Dietetics Higher Education," *Journal of Nutrition Education and Behavior,* pp. 669-674, 2016.

[4] B. Swetha, R. P. Rao, V. Rojit and V. Kumar, "A low-cost classroom response system," in *2017 International Conference on Advances in Computing, Communications and Informatics (ICACCI)*, Udupi, India, 2017.

[5] L. Crispin, "Driving Software Quality: How Test-Driven Development Impacts Software Quality," IEEE, 2006.

[6] M. V.-M. A. M. L.-L. A. P.-P. José Luis López-Quintero, "Opinions on "Classroom Response System" by first-year engineering students," in *2nd International Conference on Higher Education Advances*, València, Spain, 2016.

[7] P. B. Murray, J. A. Rossiter and G. Panoutsos, "Promoting the use of clickers across a whole engineering faculty: how, why and is it worth it?," in *International Conference on Innovation, Practice and Research in Engineering Education*, Coventry University, 2012.

[8] L. Jackowska-Strumiłło, J. Nowakowski, P. Strumiłło and P. Tomczak, "Interactive question based learning methodology and clickers: Fundamentals of Computer Science course case study," in *2013 6th International Conference on Human System Interactions (HSI)*, Sopot, Poland, 2013.

[9] M. F. E. S. R. G. A. H. Neil C. Borle, "Analyzing The Effects of Test Driven Development In GitHub," in *40th International Conference on Software Engineering*, Gothenburg, Sweden, 2018.

[10] T. D. Hellmann, A. Hosseini-Khayat and F. Maurer, "Supporting Test-Driven Development of Graphical User Interfaces Using Agile Interaction Design," in *2010 Third International Conference on Software Testing, Verification, and Validation Workshops*, Paris, France, 2010.

[11] M. Latif, Y. Lakhrissi, E. H. Nfaoui and N. Es-Sbai, "Cross platform approach for mobile application development: A survey," in *2016 International Conference on Information Technology for Organizations Development (IT4OD)*, Fez, Morocco, 2016.

[12] OmarElGabrys, "OmarElGabry's Blog," 2019. [Online]. Available: https://medium.com/omarelgabrys-blog/software-engineering-software-process-and-software-process-models-part-2-4a9d06213fdc.

[13] J. Platt, "Sequential Minimal Optimization: A Fast Algorithm for Training Support Vector Machines," 21 April 1998. [Online]. Available: https://www.microsoft.com/en-us/research/wp-content/uploads/2016/02/tr-98-14.pdf.

[14] WEKA, "WEKA Sourceforge," 2019. [Online]. Available: http://weka.sourceforge.net/doc.dev/weka/classifiers/functions/SMO.html.

[15] V. Shakya and R. R. S. Makwana, "Feature selection based intrusion detection system using the combination of DBSCAN, K-Mean++ and SMO algorithms," in *2017 International Conference on Trends in Electronics and Informatics (ICEI)*, Tirunelveli, India, 2018.

[16] B. K. R. Sangeetha, "Performance Evaluation of Kernels in Multiclass Support Vector Machines," *International Journal of Soft Computing and Engineering (IJSCE)* , pp. 130-145, 2011.

[17] L. Bottou and C.-J. Lin, "Support Vector Machine Solvers," 2019. [Online]. Available: https://www.csie.ntu.edu.tw/~cjlin/papers/bottou_lin.pdf.

[18] I. Mladenova, V. Lakshmi, J. P. Walker, D. G. Long and R. De Jeu, "An Assessment of QuikSCAT Ku-Band Scatterometer Data for Soil Moisture Sensitivity," in *IEEE Geoscience and Remote Sensing Letters (Volume: 6 , Issue: 4 , Oct. 2009)*, IEEE Geoscience and Remote Sensing Society, 2009.

[19] J. Cohen, "Statistical Power Analysis for the Behavioral Science (2nd Edition)," 1988. [Online]. Available: http://www.utstat.toronto.edu/~brunner/oldclass/378f16/readings/CohenPower.pdf.

[20] T. T. University, "Calculatin, Interpreting, and Reporting Estimates of "Effect Size" (Magnitude of an Effect or the Strength of a relation)," Texas Tech Univeristy, 2001. [Online]. Available: https://www.depts.ttu.edu/aged/toolbox/effect_size.pdf.