International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-2, July 2019

COALESCENCE: An Android-Based Instructional Application with Augmented Reality for Chemistry Students

Maria Elora Asuncion, Daryll Castromero, John Jericho Medrana, Julian Aldrin Parin, Calvin Jazer Sales, Raymund Constante, Herchel Aquines

Abstract – COALESCENCE is intended to let the Chemistry students learn and for Chemistry Teachers to use as a tool in teaching the subject. This application uses Augmented Reality to present information and 3D models of laboratory equipment, periodic elements, compound elements, and planet elements. Trivia and interactive quizzes are also provided to assess the user's knowledge. Iterative Model was applied in project development. This application was created using Photoshop, Unity 3D, Blender, and Maya. In using the application, the minimum Android OS requirement is Android 6.0 (Marshmallow) and above. The test instruments used were Functionality, Compatibility, and Conformance test aligned with Android Core App Quality Standards. It got a 100% rating for the three test instruments' used. In evaluation, Mobile Application Rating Scale was utilized with an average mean of "3.44", the standard deviation of "0.17" and an interpretation with a "Highly Acceptable" feedback from the evaluators in all aspect of the application.

Index Terms— Android Application, Augmented Reality, Chemistry, E-learning, Instructional Tool

I. INTRODUCTION

Now that K-12 program is still newly implemented for some schools along with the STEM strand which translates into Science, Technology, Engineering, and Mathematics which has the hardest subjects. One of these subjects is Chemistry; it is one of the branches of Science that occupies an intermediate position between Physics and Biology.

Chemistry is often regarded as a difficult subject, an observation which sometimes repels learners from continuing with studies in chemistry [1]. Also, according to an article published in ThoughtCo by Anne Marie Helmenstine, chemistry has a reputation as a hard class and a difficult Science to master. It has its own language; there are 118 Elements to be learned not by words but by an entire system of writing Chemical Equations plus it involves Math like Geometry and Calculus that will come in handy [2]. This can result in making the students lost because of too many information to take in and lose too much attention and concentration in studying Chemistry. Most of the public school throughout the Philippines have struggles in providing adequate tools and laboratory equipment to support better teaching. Currently, schools and universities are using the traditional way of teaching students with Chemistry like lectures on the board, charts, graphs, and flashcards for memorization and recitation techniques. While the modern way of teaching focuses more on the learner to fully involved with the use of activities with the help of technology. According to Dr. Pechenkina that most studies are into the use of mobile apps as learning tools in higher education primarily focus on apps designed to address one main aspect of the learning process, such as collaboration or motivation [3]. Through the times, different types of learning emerged as technology evolves. One of these is E-learning. It implements technology in education outside a traditional classroom set-up using electronic technologies [4]. As e-learning evolves, another platform emerged: M-Learning. It became important mode in education, as it is portable and accessible using any mobile devices both in teaching and learning purposes [5]. The learners are able to engage in educational activities without the constraints of having to do so in a tightly delimited physical location. To a certain extent, learning can happen outside a classroom or in various locations [6]. It also provides innovative learning experience.

As one of the product of technology, augmented reality has been a trend [7] and also been applied to education [8], [9], [10], [11], [12]. Augmented reality displays superimpose information in your field of view and can take you into a new world where the real and virtual worlds met [13], [14]. It lies between the real and virtual environment with a range of digital objects such as videos [15], audios, images or haptic touch can be embedded which allows the users to interact. Jamali confirmed that AR via mobile could be leveraged and used as an optimum learning in an educational context [16]. So , adding Augmented Reality can Chemistry a new view of learning by presenting samples in 3D of Periodic Elements [17], Laboratory Apparatus [18],[19] and Planet Elements which is a close representation of the real- world materials. With that said, the solution which the researchers found was to make an application which caters M-learning and AR technology make it as an instructional tool [21]

Revised Manuscript Received on 30 July 2019.
***** Correspondence Author
Maria Elora Asuncion*, COECSA-DCS, Lyceum of the Philippines University – Cavite, General Trias, Cavite, Philippines
Daryll Castromero, COECSA-DCS, Lyceum of the Philippines University – Cavite, General Trias, Cavite, Philippines
John Jericho Medrana, COECSA-DCS, Lyceum of the Philippines University – Cavite, General Trias, Cavite, Philippines
Julian Aldrin Parin, COECSA-DCS, Lyceum of the Philippines University – Cavite, General Trias, Cavite, Philippines.
Calvin Jazer Sales, COECSA-DCS, Lyceum of the Philippines University – Cavite, General Trias, Cavite, Philippines
Raymund Constante, COECSA-DCS, Lyceum of the Philippines University – Cavite, General Trias, Cavite, Philippines
Herchel Aquines, COECSA-DCS, Lyceum of the Philippines University – Cavite, General Trias, Cavite, Philippines

, [22], [23], [24] to help any students, or anyone having difficulty to understand Chemistry [25], [26], [27], [28], [29] or to learn from their teachers or instructors.

A. Objectives of the Project

The project aimed to develop "Coalescence: An Android-based Instructional Application with Augmented Reality for Chemistry Students".

Specifically, it aimed to:

1. Design a system with the following features:
   - Show a sample of 3D models of Elements, Planets and Laboratory Apparatus;
   - Display information about different elements, compounds, planets and laboratory apparatus;
   - Illustrate Atomic Structure of different elements;
   - Provide information about the chemical composition of the elements;
   - Add a text-to-speech function for convenience;
   - Include Interactive Digital and Augmented Reality Mode;
   - Assess learning thru answering trivia and quiz game [38];
   - Specify progress by showing achievements;
   - Give a guide on how to use different modes; and
   - Offer tutorial to guide the user on how to use the application
   - Download AR markers for Periodic Elements, Apparatus, and Planets
   - Create basic compound elements
2. Create a system using development tools such as Unity 3D with Android Platform and C# as a programming language, Photoshop, Blender and Maya for 2D and 3D image editing and Vuforia for the database;
3. Test and improve the system using Conformance, Compatibility, and Functionality; and
4. Evaluate the system using the Mobile Application Rating Scale.

B. Scope and Limitation

The application has basic Chemistry lessons such as Periodic Table of Elements, Compound Mixtures, 3D Laboratory Apparatus and Chemical Composition of Planets. Planets and was divided into two categories - the Terrestrial type and the Gas type.

This project could be used in school specifically for laboratory works for the subject and may come in handy for the students that may partake in, or outside of the school premises for self-learning. The user can see their progress and achievements by the stars obtained for each level. Tutorials were also included in the application for better understanding and learning. The application does not have an Online feature that allows users to connects with one another to play with the quiz. However, the application is only available to Android 6.0 and above. For best performance, it is only intended for smartphones, not a tablet.

C. Significance of the Project

These were the users that will be able to use the application. Thus, the following would benefit from the project: Students. Who are currently taking Chemistry subjects, especially Senior High with STEM Strand and College Student, to help them learn with ease without their attention-getting out of hand and to grasp the information easily with color coding and assessment that uses gamification to focus on the subject matter in this case Chemistry. Teachers. To help them to lessen the burden of bringing more visual aids, charts, or tables using the application with clear, logical, and correct 3D illustration of the objects. He/she can proceed to teach at ease because of well-written information and relevant to Chemistry.

Future Researchers. To help further improve e-learning and go beyond AR mobile instructional devices.

II. METHODOLOGY

A. Data and Process Modelling

System Flowchart. It is a visualization of data flows in a system. It discusses how the system begins, what are the inputs, the decisions in it, and the control events. Every symbol is connected by lines which determine where the data flows.

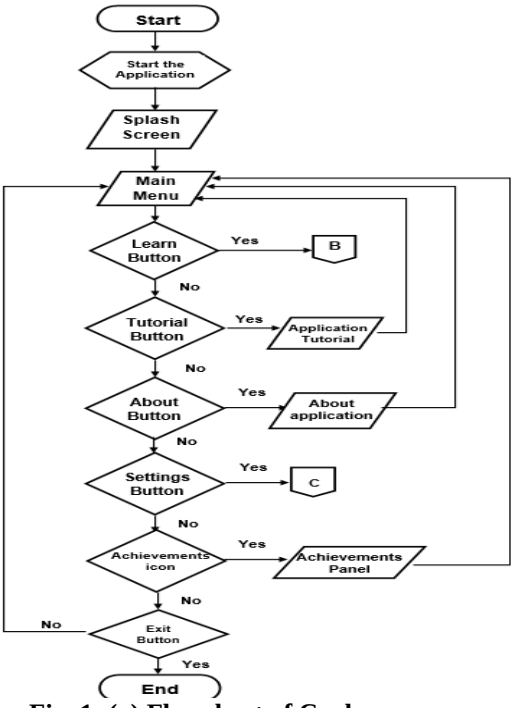

Fig. 1: (a) Flowchart of Coalescence

Fig. 1 shows the process of the application starting from the splash screen which shows the programming environment where the application was made and the developers of the application. After the splash screen, Main Menu of the application is displayed. The menu contains six buttons - Learn, Tutorial, About, Settings Icon, Achievements Icon, and Exit. The Learn button prompts the user to another part of the application containing its major features. The Tutorial Button lets the user know how to use the application. The About button contains general information about the application. The Settings Icon, subsequently, displays another window showing the Settings of the application. The Achievements Icon shows the achievements gained by the user for every assessment done. Lastly, the Exit button allows the user to close the application.

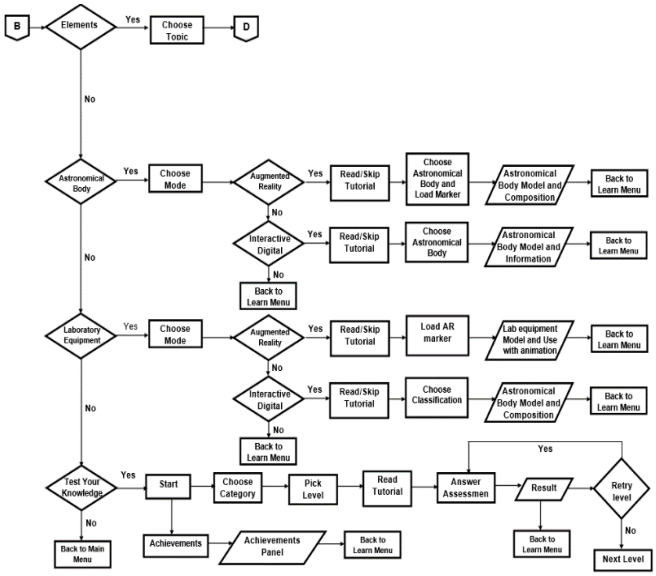

Fig. 2: (b) Flowchart of Coalescence

In fig. 2 shows the Menu under the Learn button. The first one is the Elements button which will prompt to another window once it was clicked. The second button is the Astronomical Bodies button. This button will prompt to another window containing two buttons – AR mode and Interactive Digital. The AR mode contains the 3D model of the astronomical bodies and its chemical composition. The Interactive Digital mode, on the other hand, contains information about the astronomical bodies as well as different trivia about them. The third button is the Laboratory Apparatus button. Like the other two, it also has two modes. The AR mode contains the 3D models of the apparatuses and their uses. Interactive Digital has information about apparatuses. The fourth button is the Test Your Knowledge button or the Assessment. The last one is the Back button which allows the user to go back to the Main Menu

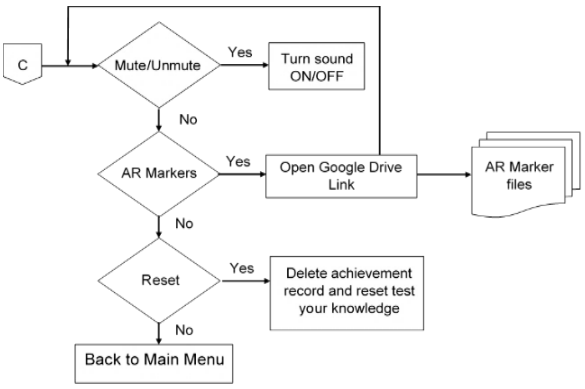

Fig. 3: (c) Flowchart of Coalescence

In Fig. 3 shows the content of the Settings Module. This one has three other buttons. These are the Mute/Unmute button when clicked, it will turn sounds on and off; AR Markers Button which will open the Google Drive link for the marker files and Reset button that erases the achievements of the user.

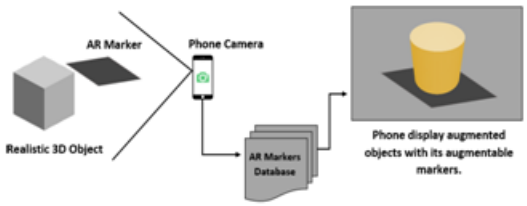

Fig. 4: AR Diagram of Coalescence

In fig. 4 shows how the augmented reality works in the application. Using the phone's camera to scan the AR markers through the phone the AR markers database will process its saved 3D model from the specific AR marker and will display on the screen of the phone. There are 4 AR marker categories in Coalescence such as Periodic Table of Elements, Compound, Astronomical Bodies, and Laboratory Apparatus.

B. Development

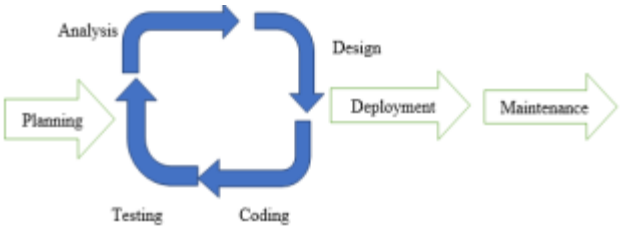

Fig. 5: Software Development Paradigm using Iterative Model

In Fig. 5 it shows that the initial stage of Iterative Model is the Planning Phase. This is where the requirements gathering is done and the time where the researchers brainstormed and research ideas and also interview Chemistry Teachers. The data gathered will be used to Analysis Stage. In this phase, the data gathered are broken down and analyzed which will be applied and essential for the project. Next, the Design phase is where the user interface design of the application is made. Then, the Coding phase is the very core of the application as this is where all of the functions of the application are developed. After that is the Testing Phase where bugs and fixes are found to be able to know which actions should be done to make the application more efficient and functional. It is tested using Functional, Conformance and Compatibility Test. These four processes mentioned are then repeated until the application is good for deployment. The deployment phase is the part where the application will be uploaded in the Play Store and is good to use. The maintenance phase is part where the application will be updated to fix bugs that may be found in later years after its first deployment or uploading a better version of the application. Software Specification. The application required an Android 6.0 Marshmallow up to the latest version Android 9.0 Pie to use the application. The researcher used Unity 3D and C# to develop the application with the used of Vuforia as SDK. SketchUp and Blender used to create the 3D model for the application, and Adobe Photoshop for better graphics of the photos and models.

Hardware Specification. The application is developed using a laptop with at least 4GB RAM with a processor of 1.5GHz to accommodate the software used. Android smartphones with 3GB RAM and free memory space of at least 380MB from Android version of 6.0 to 9.0 (Marshmallow to Pie).

C. Test Plan

The test is made is to free from errors and to know other corrections and improvements. The project was tested to check if each part of the application is functioning accordingly. The test respondents were identified as five (5) end –users, composed of two (2) teacher/professor, and three (3) students who have chemistry subject. The instruments used are for conformance, compatibility, and functionality. The application was tested using mobile phones with Android OS versions 6.0, 7.0, 8.0, and 9.0. Test Instrument. The test instruments relevant to the characteristics and functions of the application guided this activity. These test tools are Compatibility, Conformance, and Functionality test. The Compatibility test was used to check if the application would work consistently using different versions of the Android platform from 6.0, Marshmallow 7.0 Nougat, 8.0 Oreo, to the latest 9.0 Pie. Furthermore, the Functionality test was used to know if each module and sub-parts of the application is performing as intended and if there are no bugs encountered. Conformance test was conducted to know if the application conforms with the Android Core App Quality Standard.

D. Verification, Validation, and Testing

This is the method of evaluating the conditions imposed at the start and the specification requirements for the application. The proponents did testing if it meets objectives and its purpose to target users. Compatibility Testing. This testing is done to ensure that the application runs on different Android versions, and mobile resolution. Conducting compatibility testing is important for the users to know if the application function as expected by the users, this is to ensure the user experience is working properly as stated by Fern, David in his article entitled" What is Mobile Device Compatibility Testing?". It was also stated that there are many types of issues regarding compatibility that affects user experience like content, navigation, functions, and features [29]. Conformance Testing. The application used the Android Core App Quality Standard for conformance testing. It is done to ensure that the application complies with the required specifications and standards. The application must pass this test to guarantee its quality. As stated by Margaret Rouse in her article about conformance testing, its standards are said to be defined by large entities like the Institute of Electrical and Electronics Engineering (IEEE), the World Wide Web Consortium or the European Telecommunications Standards Institute (ETSI). Rouse also stated that once a program or application passed the standards provided, it may now be advertised for use as it is certified [30]. Functionality Testing. This testing is done to make sure that the different function of the application buttons, icons, and other content works perfectly. It is also stated in an article by Nandini KS that functionality testing to confirm that the requirements specified firsthand are met as well as the user needs. Functionality testing is also not limited to only one type of mobile application but also, includes both Android-based applications and iOS-based applications. The testing is done based on the requirements specified and ensures that the features identified run as expected with no errors [31]. Test Criteria. The criteria were conducted to ensure the software is functioning as intended per test instrument. The test phase was successfully passed the criteria. The respondents checked the application if Passed or Failed with the given criteria.

E. Evaluation Plan

The evaluation step is the acceptability of the application to the users. This was performed to prove that the project positively serves its purpose. The evaluation tool used was based on the Mobile Application Rating Scale or MARS. For Thirty-nine (39) end-users, the proponents have a classroom setup, which is composed of thirty-four (34) senior high students, two (2) chemist and three (3) chemistry teachers and eleven (11) IT experts were invited to perform this activity. The device used is mobile phones running Android platform versions 6.0, 7.0, 8.0, and 9.0 with a minimum of 3GB RAM. Evaluation Data. The evaluation instrument used in the project was based on the MARS [32]. This instrument with the criteria of five which are Engagement, Functionality, Aesthetics, Information and Google Play helps the Evaluator to accurately score the application based on the scoring system in Table II.Statistical Treatment of Data. The data were gathered from a total of fifty (50) evaluation respondents. The collected data were computed and undergone data interpretation and validation based on the weighted mean and standard deviation. The following are the formulas used by the researchers. Weighted Mean. It is a kind of average, instead of each data point contributing equally to the final mean [33]. The mean is the arithmetic average of the scores that were given by the test respondents. X is the summation of the total scores and N is the total number of respondents. Standard Deviation. This is the measure of the dispersion of a set of data from its mean. It measures the absolute variability of distribution; the higher the dispersion or variability, the greater is the standard deviation and greater will be the magnitude of the deviation of the value from their mean. [34]. First, input the raw data in the excel table prepared by the researchers to easily separate each criterion from one another. After that, the excel has the function to extract SD from the data gathered from the evaluators. Likert Scale. The researchers used the Likert scale in measuring the respondents' acceptability level from the questionnaires guided by the criteria presented in the recommended evaluation instrument.

Table I: LIKERT SCALE OF COALESCENCE

Likert Scale	
3.26 – 4.00	Highly Acceptable
2.51 – 3.25	Acceptable
1.76 – 2.50	Fairly Acceptable
1.00 – 1.75	Unacceptable

The table I shows the levels of acceptability of the software evaluated. From "1.00" to "1.75" it is "Unacceptable", which means the application might have failed to execute its main functions; "1.76" to "2.50" is "Fairly Acceptable" somehow the application have executed but lack of consistency to function well; "2.51" to "3.25" is "Acceptable" means that the features of the application almost meet its expected result and lastly "3.26" to "4.00" is "Highly Acceptable" where the overall functions and objectives of the application works smoothly.Evaluation Criteria. The evaluation criteria are accomplished to specify the modules of the application. The criteria are the 'Engagement' which has sub criteria the entertainment, interest, customization, interactivity, and target group. 'Functionality' which has sub criteria the performance, ease of use, navigation, and gestural design. 'Aesthetics' which has sub criteria the layout, graphics, and visual appeal. The 'Information' which has sub criteria the Accuracy of App Description (in App Store), goals, quality of information, the quantity of information and visual information. Lastly 'Google Play store' the sub-criteria are notification, permissions, install location and app details page. The criteria and sub-criteria for mobile application are based on the Mobile Application Rating Scale.

Table II: Scoring System of Coalescence

Scoring System	
Numerical Rating	**Equivalent**
4	Highly Acceptable
3	Acceptable
2	Fairly Acceptable
1	Unacceptable

The scoring system of the evaluation shows in Table 2. If the score is 4 it is "Highly Acceptable" and if it is 3, it is "Acceptable", and if the score is 2 it is "Fairly Acceptable". The lowest score is 1.00 equivalents to "Unacceptable".

III. RESULTS AND DISCUSSION

A.Design

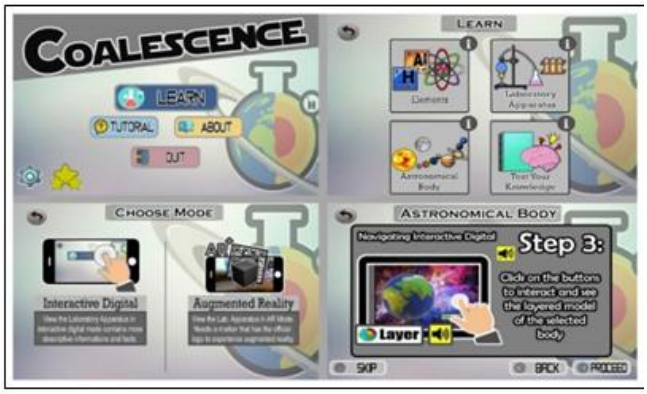

Fig. 6: Main Window of Coalescence

Figure 6 shows the main windows that Coalescence has. It contains four different topics, each have its own mode to choose the Interactive Digital Mode and Augmented Reality Mode. It also has a step-by-step tutorial for every topic and mode.

Fig. 7: Augmented Reality Mode of Coalescence

Fig. 7 shows the Augmented Reality mode of the application. Augmented Reality works with the customized marker; it is needed for the 3D models to show. Most of the augmented objects are interactive.

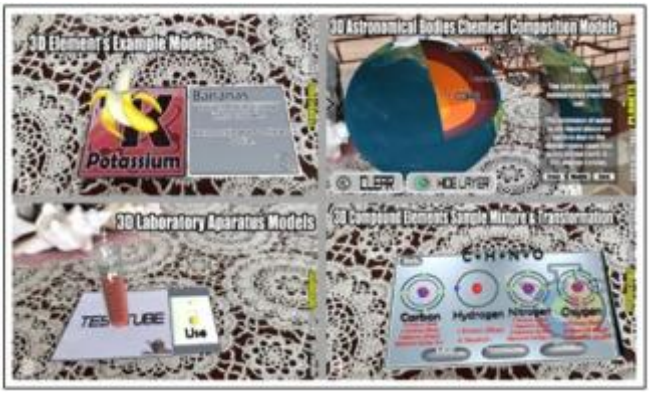

Fig. 8: Interactive Digital Mode of Coalescence

Fig. 8 shows the Interactive Digital mode of the application in this features the four topics are discussed briefly. Every topic is categorized and has different virtual buttons for interactions.

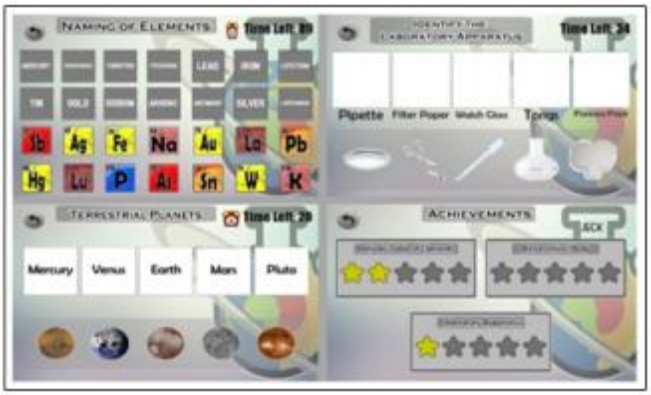

Fig. 9: Test Your Knowledge of Coalescence

Fig. 9 shows the Test Your Knowledge of the application, it contains different topics with different levels to unlock and pass in order to earn star from the Achievements. Every level has a time limit.

B. Test Results

The application went through a series of tests. The testing instruments that were conducted are compatibility, conformance, and functionality and tested by End-users, technical adviser. End-users are composed of the technical adviser, two teachers/professor, and three students undertaking Chemistry subject.

TABLE III. TEST RESULTS OF COALESCENCE FUNCTIONALITY

Test Respondent	Pass	Fail	Test Criteria	Percentage
Technical Adviser	56	0	56	100%
End-Users	56	0	56	100%

Functionality test was done with 56 criteria. Both Technical Adviser and two teachers got 56 passed and 0 failed, with 100% passing rate; same goes with the students with 56 passed and 0 failed to result in a 100% passing rate.

TABLE IV. TEST RESULTS OF COALESCENCE CONFORMANCE

Test Respondent	Pass	Fail	Test Criteria	Percentage
Technical Adviser	24	0	24	100%
End-Users	24	0	24	100%

The compliance to the Conformance Test (Android Core App Standard) got also a high percentage of 100% both Technical Adviser and end-users with the test conducted with 24 test criteria; the students resulted with 100% passing rate with 24 test criteria.

TABLE V. TEST RESULTS OF COALESCENCE COMPATIBILITY

Test Respondent	Pass	Fail	Test Criteria	Percentage
Technical Adviser	13	0	13	100%
End-Users	13	0	13	100%

All the test participants passed the compatibility test with a 100% passing rate from the thirteen (13) test criteria. Compatibility test results showed that the application is proficient enough to run in the hardware screen resolution of 720 x 1280 with a screen ratio of 18:9 and Android OS versions specifically 6.0, 7.0, 8.0 and 9.0.

C.Evaluation Results

The evaluation phase assessed the level of the user's acceptability of the application. The evaluation used was based on the Mobile Application Rating Scale (MARS) and done by thirty-nine (39) end users, and eleven (11) IT experts.

TABLE VI. OVERALL EVALUATION (MARS) RESULTS

Criteria	Mean	SD	Interpretation	Rank
Engagement	3.41	0.46	Highly Acceptable	5
Functionality	3.48	0.06	Highly Acceptable	1
Aesthetics	3.47	0.08	Highly Acceptable	2
Information	3.43	0.19	Highly Acceptable	3
Google Play	3.42	0.08	Highly Acceptable	4
Average Mean	**3.44**	**0.17**	**Highly Acceptable**	
and SD				

The overall evaluation results for the application composed of (11) I.T. Experts, (39) End-users which composed of (3) chemistry teacher, (2) practitioner of chemistry in the industry and validated and (34) senior high students. The highest rank in the overall results is the "Functionality" criteria with a mean of 3.48 and a 0.06 Standard deviation which is highly acceptable which mean the application is easy to use and work accurately fast.

The second is "Aesthetics" criteria with a mean of 3.47 and a 0.08 standard deviation which is highly acceptable which has good quality or resolution of the graphics is high and application looks good.

The third is "Information" criteria with a mean of 3.43 and a 0.19 standard deviation which is highly acceptable due to its information are highly accurate with quality and quantity that is relevant to the topic.

The fourth is the "Google Play" criteria with a mean of 3.42 and a 0.08 standard deviation which is highly acceptable which used permission to its absolute minimum and accurate app detail page and a working install location.

And lastly at the lowest rank "Engagement" with a mean of 3.41 and a 0.46 standard deviation which is still a highly acceptable interpretation but because of there is no other way for the user to give feedback other than the google play receives a low rating.

IV. CONCLUSION AND FUTURE WORKS

The project "COALESCENCE: An Android-based Instructional Application with Augmented Reality for Chemistry Students" achieved all of its objectives.

The project Coalescence is only available to mobile Android users, specifically for the smartphone. The project required a 3GB RAM with a minimum of Android OS version 6.0 and above with a minimum of 720 x 1280 resolution with a screen ratio of 18:9. In creating the project, it utilized the Iterative Model. The application was tested according to functionality, conformance and compatibility test cases with the help of testers that are two teachers, and three students. The modules of the application were functioning as expected and received a score of 100%; All of the given standards from the Android Core App Quality were applied and received a 100% score; lastly the compatibility test acquired also a 100% passing score, which showed that the application can run efficiently from Android version 6.0 to 9.0 and displayed UI on a recommended screen resolution and hardware specification. The user's acceptability of the application was interpreted as "Highly Acceptable" from the evaluators of thirty-nine (39) end-users and eleven (11) IT experts using the Mobile Application Rating Scale. The project earned an overall mean of "3.41" and an SD of "0.46" with an interpretation of "Highly Acceptable". Based on the evaluation results, the users found that the application was entertaining, user-friendly, aesthetically appealing, and nformative in learning basic Chemistry for the students, who are currently taking Chemistry.

To enhance the application, the future enhancement of the project are the following:

• The additional advance lesson, compound mixtures of the elements & different computation;

• Develop an online session for students can connect with friends/classmates to compete and a unique user name;

• More Interactive GUI for Games and more types of assessment like identification, matching type, enumeration & computations; and

• Add a scoring feature in the assessment to let the user know their standing in each type of assessment

REFERENCES

1. G. Sirhan. (2007, September) "Learning Difficulties in Chemistry: An Overview." Available: http://www.tused.org/internet/tufed/arsiv/v4/i2/metin/tusedv4i2s1.pdf
2. A. Helmenstine, AM, Ph.D. (2019, January 19). "Why Is Chemistry So Hard?" Available: from https://www.thoughtco.com/why-is-chemistry-so-hard-604145
3. E. Pechenkina, D. Laurenc, G. Oates, D. Eldridge, and E. Hunter, "Using a gamified mobile app to increase student engagement, retention and academic achievement." International Journal of Educational Technology in Higher Education, 2017; 14 (1) DOI: 10.1186/s41239-017-0069-7
4. (N.A) "What is eLearning?" Available: http://www.elearningnc.gov/about_elearning/what_is_elearning/ov/about_elearning/what_is_elearning/
5. R. Kirubakaran, X. Jency, and D. Aswini. (2018, December) "Mobile Learning for Education in India - A Feasibility Study" Available https://www.ijrte.org/wp-content/uploads/papers/v7i4s2/ES2087017518.pdf
6. (N.A) "The University of Sydney" (2018, January) MOBILE LEARNING Available: http://sydney.edu.au/education_social_work/learning_teaching/ict/theory/mobile_learning.shtml
7. N. F. Saidin, N. Abd Halim, and N Yahaya, (2015, June) "Augmented Reality Trends in Education: A Systematic Review of Research and Applications"
8. M. Bower, C. Howe, N. McCredie, A. Robinson, and D. Grover, (2014). "Augmented Reality in education–cases, places, and potentials" Educational Media International, 51(1), 1-15.
9. S. Küçük, S. Kapakin, and Y. Göktaş, (2016). "Learning anatomy via mobile augmented reality: effects on achievement and cognitive load". Anatomical sciences education, 9(5), 411-421.
10. C. Lytridis, A. Tsinakos, and I. Kazanidis, I. (2018). "ATutor—An Augmented Reality Platform for Interactive Distance Learning." Education Sciences, 8(1), 6.
11. D. Nincarean, M. Alia, N. Halim, and M. Rahman, (2013). "Mobile augmented reality: The potential for education." Procedia-Social and Behavioral Sciences, 103, 657-664.
12. Z. Rongting, S. Yiran, H. Tongliang and F. Asmi, "Applying Augmented Reality Technology to E-Learning: Science Educational AR Products as an Example," 2016. IEEE 13th International Conference on e-Business Engineering (ICEBE), Macau, 2016, pp. 129-133. doi: 10.1109/ICEBE.2016.030
13. V. Aggarwal, (n.d.) "AUGMENTED REALITY – INTRODUCTION AND ITS REAL WORLD USES" Available: https://www.3pillarglobal.com/insights/augmented-reality-introduction-and-its-real-world-uses
14. Q. Liu, S. Huang and T. Han (2017, October). "Fast and accurate object analysis at the edge for mobile augmented reality." In Proceedings of the Second ACM/IEEE Symposium on Edge Computing (p. 33). ACM.
15. I. Kazanidis, G. Palaigeorgiou, A. Papadopoulou and A. Tsinakos, (2018). "Augmented Interactive Video: Enhancing Video Interactivity for the School Classroom." Journal of Engineering Science and Technology Review, 11(2), 174-181.
16. J. Siti Salmi (2019, April) "The Effects of using Mobile-Augmented Reality Learning Environment with Cognitive and Affective Learning Outcomes using Structural Equation Modeling Approach." Available https://www.ijrte.org/wp-content/uploads/papers/v7i6s2/F10240476S219.pdf
17. D. Armijo, M. Curiano, P. Honrada, D. Parreño, and J. Tolentino, (2018, May) "FOCAL: An Android AR Scanner of the Periodic Table of Element. Lyceum of the Philippines University – Cavite", p.1-6
18. M. Chen and B. Liao, "Augmented Reality Laboratory for High School Electrochemistry Course," 2015 IEEE 15th International Conference on Advanced Learning Technologies, Hualien, 2015, pp. 132-136. doi: 10.1109/ICALT.2015.105
19. H. Hou and Y. Lin, "The Development and Evaluation of an Educational Game Integrated with Augmented Reality and Virtual Laboratory for Chemistry Experiment Learning," 2017 6th IIAI International Congress on Advanced Applied Informatics (IIAI-AAI), Hamamatsu, 2017, pp. 1005-1006. doi: 10.1109/IIAI-AAI.2017.14
20. G. Awa, K. Contemprato, J. Labis, and M. Reyes, (2015, March). "ELEMENTO: AN ELECTRONIC PERIODIC TABLE WITH MOLAR COMPUTATIONS FOR ANDROID OS". Lyceum of the Philippines University – Cavite, p. 1-6, 8-10
21. K. Dutta, (2015 February) "Augmented Reality for E-Learning"
22. P. Jain, J. Manweiler, and R. Choudhury, (2015, May)." Overlay: Practical mobile augmented reality". In Proceedings of the 13th Annual International Conference on Mobile Systems, Applications, and Services (pp. 331-344). ACM.
23. M. Specht, (2013, January) "Mobile Augmented Reality for Learning"
24. Android Core App Quality. (n.a) (n.d) Available: https://developer.android.com/docs/quality-guidelines/core-app-quality
25. H. Brandt, M. Georgsen, B. Nielsen, and H. Swensen, (n.d) "Augmented Reality for Science Education"
26. T. Chiang, S. Yang, and G. Hwang, (2014). "An augmented reality-based mobile learning system to improve students' learning achievements and motivations in natural science inquiry activities." Educational Technology & Society, 17(4), 352-365
27. U. Köse, D. Koc and S. Yücesoy, S. (2013, December) "An Augmented Reality based Mobile Software to Support Learning Experiences in Computer Science Courses" Available: https://www.researchgate.net/publication/259167615_An_Augmented_Reality_based_Mobile_Software_to_Support_Learning_Experiences_in_Computer_ScienceCourses
28. M. Fjeld and B. M. Voegtli, "Augmented Chemistry: an interactive educational workbench," Proceedings. International Symposium on Mixed and Augmented Reality, Darmstadt, Germany, 2002, pp. 259-321. doi: 10.1109/ISMAR.2002.1115100
29. D. Fern, (2015, Aug). "What Is Mobile Device Compatibility Testing?" Available: https://digital.gov/2015/08/14/what-is-mobile-device-compatibility-testing/
30. M. Rouse, M. (2007, February). "Conformance Testing". Available: https://searchsoftwarequality.techtarget.com/definition/conformance-testing
31. K. Nandini, (2018, March) "Functional Testing for Mobile Application – Basic and General Validation." Available: http://www.helpingtesters.com/mobile-application-functional-testing/
32. S. Stoyanov, L. Hides, D. Kavanagh, Z. Oksana, D. Tjondronegoro, and M. Madhavan. (2015)."Mobile App Rating Scale: A New Tool for Assessing the Quality of Health Mobile Apps. JMIR mHealth uHealth". 3. e27. 10.2196/mhealth.3422.
33. Weighted Mean. (n.d) SurveyAnalytics by Question Pro. Available: https://www.surveyanalytics.com/help/weighted-mean.html
34. Standard Deviation. (n.d) Statistics how to. Available: https://www.statisticshowto.datasciencecentral.com/probability-and-statistics/standard-deviation/

AUTHORS PROFILE

Maria Elora Asuncion. is a student from Lyceum of the Philippines University - Cavite Campus, she is studying Bachelor of Science in Information Technology. She conducted her internship at Hayakawa Electronic (Phils.) Corp. A persistent Dean's Lister.

Daryll Castromero. He is a student from Lyceum of the Philippines University - Cavite Campus, he is studying Bachelor of Science in Information Technology. He conducted his internship at Htech Alabang.

John Jericho Medrana. A student from Lyceum of the Philippines University - Cavite Campus, he is studying Bachelor of Science in Information Technology. He conducted his internship at Tagaytay Highlands International Golf Club's Information Technology and Telecommunication Department.

Julian Aldrin Parin. a student from Lyceum of the Philippines University - Cavite Campus, he is studying Bachelor of Science in Information Technology. He conducted his internship at Analog Device Inc.

Calvin Jazer Sales. He is a student from Lyceum of the Philippines University - Cavite Campus, he is studying Bachelor of Science in Information Technology. He conducted his internship EagleRidge Golf & Country Club.

Raymund Constante. He is a regular faculty member of the Department of Computer Studies. His email is raymund.constante@lpu.edu.ph

Herchel Aquines. She is the Coordinator of Department of Computer Studies in Lyceum of the Philippines University - Cavite. She got her Master's Degree in Information Technology in TUP – Manila last April 2016. She is the adviser of LPU-Cavite Student Association for Technological Advancement Organization. Her email is herchel.aquines@lpu.edu.ph Her ORCID number is orcid.org/0000-0001-5541-2932.