ELINVO (Electronics, Informatics, and Vocational Education), Mei 2023; vol 8(1): 103-112
ISSN 2580-6424 (printed), ISSN 2477-2399 (online) DOI: https://doi.org/10.21831/elinvo.v8i1.55729

Development of an Android-Based Cultural Heritage Map App

Muhammad Irfan Luthfi[1*], Ratna Wardani[2,] Nisa Dwi Septiyanti[3]
[1,2] Electronics and Informatics Engineering Education, Universitas Negeri Yogyakarta, Indonesia
[1] Graduate Institute of Network Learning Technology, National Central University, Taiwan
[3]Universitas Muhammadiyah Karanganyar
[*]E-mail: m.irfanluthfi@uny.ac.id

ABSTRACT

This study aims to (1) develop an Android-based cultural heritage map app that can provide the location of cultural heritages in the Special Region in Yogyakarta along with its descriptions, images, and videos; and (2) understand the quality of the app based on standard software quality testing ISO / IEC 25010 on functional suitability, performance efficiency, and compatibility. The development method utilized a waterfall software development model that consists of communication, planning, modeling, construction, and deployment. The results of this study are 1) an Android-based cultural heritage map app that can provide the location of cultural heritages in the Special Region of Yogyakarta along with its descriptions, pictures, and videos. and 2) the test results indicate the app meets the standards of ISO / IEC 25010 on the aspect of (1) functional suitability, entire functions of the app running 100%, (2) the compatibility of the app, compatible 100% of the co-existence, various operating systems, device types, and screen dimensions, (3) performance efficiency, the app successfully executed in 312 of the 321 test devices without any memory leak with the average of time behavior, CPU utilization, and memory utilization for Dalvik Virtual Machine are 0.022 seconds/thread, 10.71%, and 33.11 MB and the average of time behavior, CPU utilization, and memory utilization for Android Run Time are 0.020 seconds/thread, 9.9918%, and 154.582 MB.

Keywords*:* history, cultural heritage, mobile app, map-based app, ISO/IEC 25010

INTRODUCTION

All past events are History. History can help an individual to understand human life past, present, and future [3]. People who study History are more ready to deal with today's problems by understanding past decisions. Moreover, people can understand each decision's different options, benefits, and consequences. Studying History also improves critical thinking skills because it requires people's ability to analyze and make arguments about things and support their opinions with evidence [24].

At school, historical subjects are in the Social Sciences study group. Many students view historical subjects as boring because the learning is considered nothing more than a series of year numbers and a sequence of events that must be remembered and then revealed again when answering exam questions [35]. Thus, to overcome the tedious learning process, more varied models can be applied and utilize the existing instructional media in schools to the maximum and appropriately within and outside the school following the learning material [11].

One of the popular models used for learning History is the field trip model. This model has long been used in social studies as a teaching and learning context, especially in historical subjects. Field trips allow students to build knowledge actively through interactions with historical sites, experts, and artifacts. Field trips can be one of the most valuable and effective ways of teaching History, especially about local historical sites when integrated into the curriculum and not used as a reward [20]. However, this model has drawbacks, one of which is that it requires a lot of money and has to schedule outside learning activities at school [19]. Therefore, many teachers are now using Virtual Field Trips (VFTs), which offer more accessible access to historical sites or artifacts than traditional Field Trips through some internet-connected app or other distance learning network. [31].

Furthermore, several studies have already been conducted by some scholars. For example, research by Smith and Johnson (2022) investigates using digital technology in history lessons to raise awareness and preserve cultural heritage. However, this research has limitations because it only limits the use of digital technology and does not explore the social, political, and economic factors that affect the preservation of cultural heritage [25]. Another study by Chen and Lee [5] highlights the role of historical museums in enhancing the preservation of cultural heritage through participatory learning. Nonetheless, this research is limited to the role of historical museums. It does not investigate the contribution of other institutions, such as educational institutions and government, in preserving cultural heritage [5]. Brown and Wilson [4] researched project-based history education to increase awareness and preserve cultural heritage in secondary schools. However, this research only focuses on history education in secondary schools. It does not consider the context of learning History at other educational levels or outside the school environment [4]. Finally, Garcia and Martinez [10] researched community-based History learning to encourage participation in preserving local cultural heritage. However, this research has limitations because it only considers history lessons involving local communities and does not explore the implications and challenges that may be related to different cultural and geographical factors [10].

Therefore, starting from the problems described, we developed an app that allows teachers and students to learn History virtually using smartphones. This is our second study after [16], which focuses on system development but not on the level of system implementation to users. Our study regarding the implementation of the system to users will be our study in the future. The app we developed mapped cultural heritage, evidence of History, and cultural heritage in the Special Region of Yogyakarta using Google Maps. We developed this app for the Android platform, which is still the most popular mobile operating system in 2022 [26]. In addition to developing this app, we also tested it to meet software quality standards ISO/IEC 25010 [13] modified by David [6] for mobile software.

A history study involves the study and documentation of the past [14]. Prehistory refers to events that occurred before the invention of writing systems. The term "history" encompasses the memory, discovery, collection, organization, presentation, and interpretation of past events. By utilizing written documents, oral accounts, artifacts, ecology markers, and artifacts, historians seek to understand the past [1].

The academic discipline of History uses narratives to describe, examine, question, and analyze past events and investigate their patterns of cause and effect [8][17]. An essential topic among historians is which narrative best explains an event and the significance of the various causes and effects. Several historians argue that History is both an end and a helpful tool for providing perspective on contemporary issues [8][18][27][30][34].

Cultures consider their cultural heritage or legends when there is no external support for familiar stories[23][7]. Myths are not supported by evidence, whereas History does. Cultures have evolved in their interpretation of History and continue to change today because of ancient cultural influences. Modern History encompasses various topics, including particular regions and specific topics or thematic elements. Education at all levels emphasizes the study of History.

The use of mobile devices can enhance historical imagination and facilitate various activities related to historical thinking and learning [15]. By providing additional information via the web, mobile devices can enhance a visit to a real place. One example is QR codes attached to an object. When QR codes are scanned, long URLs open in the device's browser, allowing users to access additional materials, including text, sound files, images, videos, and interactive quizzes. Students may acquire these materials via the web to learn about the properties and History of an object or a historically distinct landscape [15].

Multifunctional gadgets such as mobile devices can be used in many ways. We can use them to write, create audio and video recordings, and locate exciting sites. Students can analyze, comprehend, and validate historical sources using these technologies in a new and creative way. Using mobile technologies, we can create narratives about History, tell stories, and develop the imagination of the past[2]. Moreover, a study conducted by [12] and Wardani [32] also found that it had a positive effect when users could interact with the real world with their mobile devices.

Geolocation and digital maps play a crucial role in the spatial dimension of history teaching and learning. The use of mobile devices in outdoor environments facilitates orientation. These tools can help students locate, identify, and perceive places and buildings in their actual and historical surroundings. The GPS function of a mobile device allows students to measure distances between locations, buildings, or institutions. The records made outside environments can be analyzed and used in the classroom as self-made learning materials [9].

By using Google Maps, students can get a better understanding of people and places. For example, a student can combine landmark searches with History learning by using the overlay tool. Using overlay tools, historical images can be virtually placed over modern maps to create a sense of place, such as aerial photographs, engravings, drawings, etc. [29]. For example, showing a city before a fire or bombing can enable students to comprehend the extent of the event. Additionally, [33] stated that Google Maps are excellent for visualizing locations. In addition, it is still helpful for students to understand how places are related to each other as they create both authentic and fictional trips.

Unfortunately, Sauer [22] found that many students lack the competencies for accuracy, which should be considered when planning lessons. Integrating mobile devices and their capabilities into teaching allows teachers to foster map-reading and orientation skills using an activity-oriented approach to historical learning. Furthermore, by utilizing active and constructivist approaches, learners can also strengthen their mapping skills by creating digital maps, for example, in or outside of the classroom. Various services, including Google Maps, OpenStreetMap, and Stepmap, provide such functions [28]. Learning scenarios along these lines might involve students using mobile devices to study maps, their design and information value, and the process of creating and annotating maps.

Although no empirical study has been conducted on mobile History learning, König & Bernsen [15] suggest that learning history lessons using mobile devices is most suitable for inquiry- and design-based learning scenarios. Mobile devices allow students to connect their learning process with their living and working environment in contexts where learning is highly situated and location-based.

METHODS

A. Development Model

The development of this app uses the waterfall model. The waterfall model is a classical model that is systematic and sequential in building software [21]. Figure 1 shows the sequence of this development model.

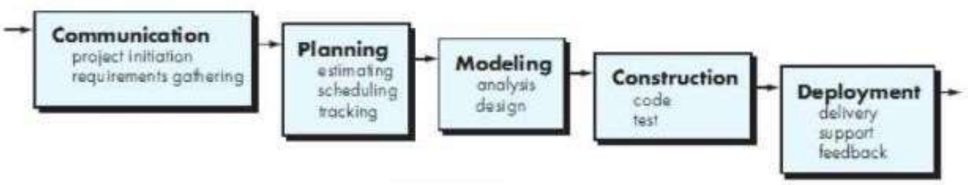

Figure 1. Waterfall Model [21]

There are five stages in this model: (1) Communication: by conducting a needs analysis to get the specific needs needed and following the needs of the user; (2) Planning: by making schedules that include the time required for needs analysis, product development, to testing; (3) Modelling: include system and software design, including UX and UI design. It involves analyzing requirements, creating designs, data modeling, and validation, emphasizing structured development for a user-friendly software system; (4) Construction: by doing software development and testing to find bugs in the released software; (5) Deployment by doing software deployment to users to be evaluated and provide feedback.

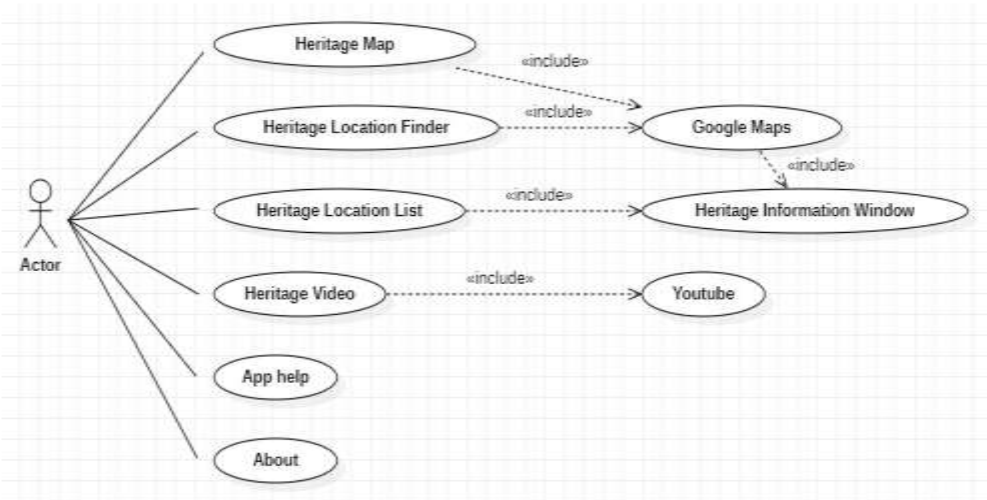

Figure 2. Use Case Diagram

C. Testing Method

To ensure the quality of the developed app, we employed the ISO/IEC 20510 software quality testing standard modified by Ben David [6] on three aspects: (1) functional suitability: by employing a questionnaire containing a list of software functions and utilizing the expert judgment method; (2) compatibility by utilizing AWS Device Farm Automation Testing Tool to test software quality in Coexistence, Operating System, Device, Screen Dimension; and (3) performance efficiency also utilize AWS Device Farm Automation Testing Tool to test software quality in Time Behaviour, CPU Resource Utilization, and Memory Resource Utilization.

D. Analysis Method

We also employ a simple analysis technique to understand the app's quality in the function suitability aspect. The following simple formula calculates the result of the test.

$$QP(\%) = \frac{Test\ result\ score}{Expected\ score} x\ 100\% \quad (1)$$

**QP(%) = Quality Percentage (%)*

After getting the result, we interpret it into statements according to Table 1.

Table 1. Result Interpretation [27]

QP	Interpretation
0% - 20%	Not Very Good
21% - 40%	Not Good
41% - 60%	Good Enough
61% - 80%	Good
81% - 100%	Very Good

Meanwhile, the compatibility and performance analysis will utilize the AWS Device Farm Automation Testing Tool.

Figure 5. Sketch designs, paper-based designs, and digital designs [16]

RESULT AND DISCUSSION

A. System Development

We developed the app in five stages: (1) Communication: the result of this stage is that the developed app must be able to support the learning process inside or outside the classroom. In addition, the app must also be able to provide the location of cultural heritage, descriptions, images, and videos using an Android device. Therefore, we developed the app on the minimum Android operating system version 4.1, and the minimum screen dimension is small (LDPI); (2) Planning: At this stage, we planned for nine months to finish building the app from the first stage (communication) to the last stage (deployment); (3) Modelling: At this stage, we designed the app's UX (Use Case diagrams, Sequence diagrams, and Activity diagrams) and app's UI design. Figures 2, 3, and 4 show examples of Use Case diagrams, Sequence diagrams, and Activity diagrams; (4) Construction: In this stage, we developed content markers for cultural heritage locations, developed maps with the Google Maps API, developed and optimizing content, developed databases, developed app layouts, developed programming logic, debugging, conducted IARC (International Age Rating Coalition) certification, and built releases. The whole process of development construction produces a complete app that is ready to be tested; (5) Deployment: In this stage, we deployed the app through the website, social media, and two Android mobile app stores: the Google Play Store and the Opera Mobile Store.

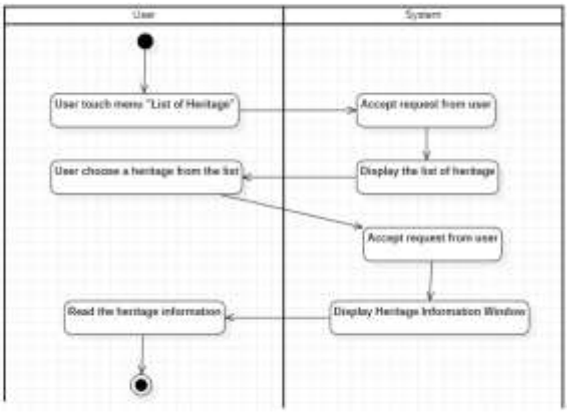

Figure 3. Activity Diagram

Figure 4. Sequence Diagram

At the modeling stage, we designed two types of designs: UX Design and UI Design. UX Design is a design that describes the workflow of the app. We used Use Case diagrams, Sequence diagrams, and Activity diagrams to describe the app's workflow. Meanwhile, we designed sketch, paper-based, and digital designs in UI Design (Figure 5).

Finally, after we completed the modeling stage, we began the construction process to build the design into a complete app ready to be used and tested by users. Figure 6 shows the complete app ready to be used and tested by users.

B. *Testing Device*

We used eleven devices available on the AWS Device Farm for the testing device. The devices were LG G2, Samsung Galaxy SIII, LG Nexus 5, Motorola DROID RAZR M, HTC One M8, OnePlus One, Motorola Nexus 6, Samsung Galaxy Note 4, Motorola Moto G – 2nd Gen, Motorola DROID Turbo and Samsung Galaxy S7. We chose these devices because they met the criteria for the diversity of the Android operating system, CPU, memory, and screen dimensions. In addition, we also used all 321 test devices available on the AWS Device Farm to obtain test results accurately.

C. *Functional Suitability Testing*

We conducted a functional suitability test by inviting five experts from various IT professions who understand systematic software. The test result is 100%. These results indicate that all app functions can run well to meet functional suitability standards.

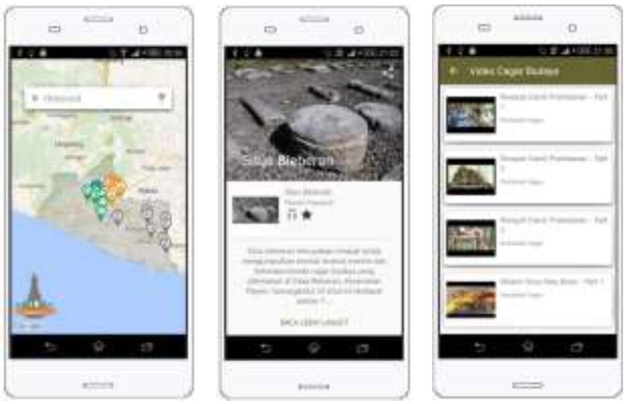

Figure 6. Final product before testing and deployment

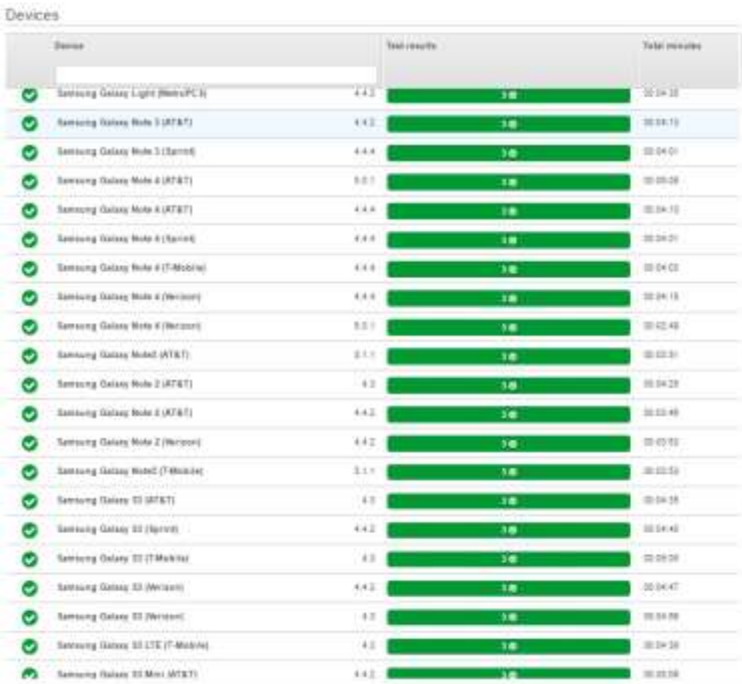

Figure 7. Compatibility testing on aspects of the operating system in various versions of Android

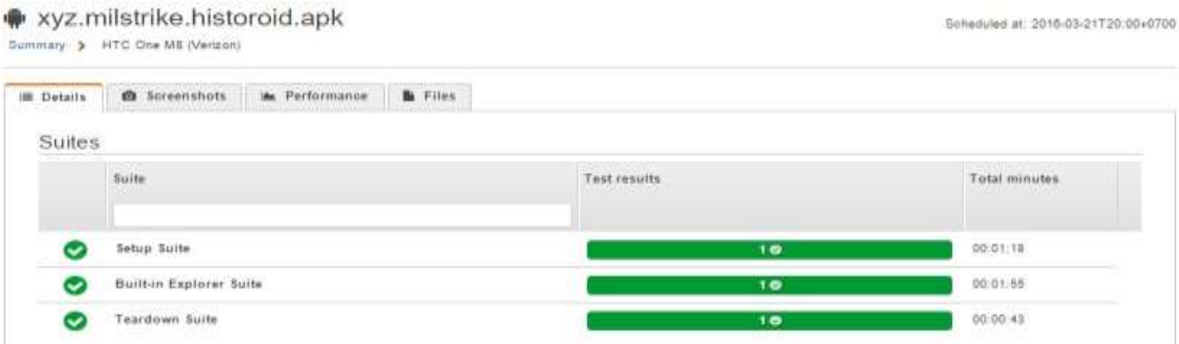

Figure 8. Compatibility testing on aspects of the devices in HTC One M8

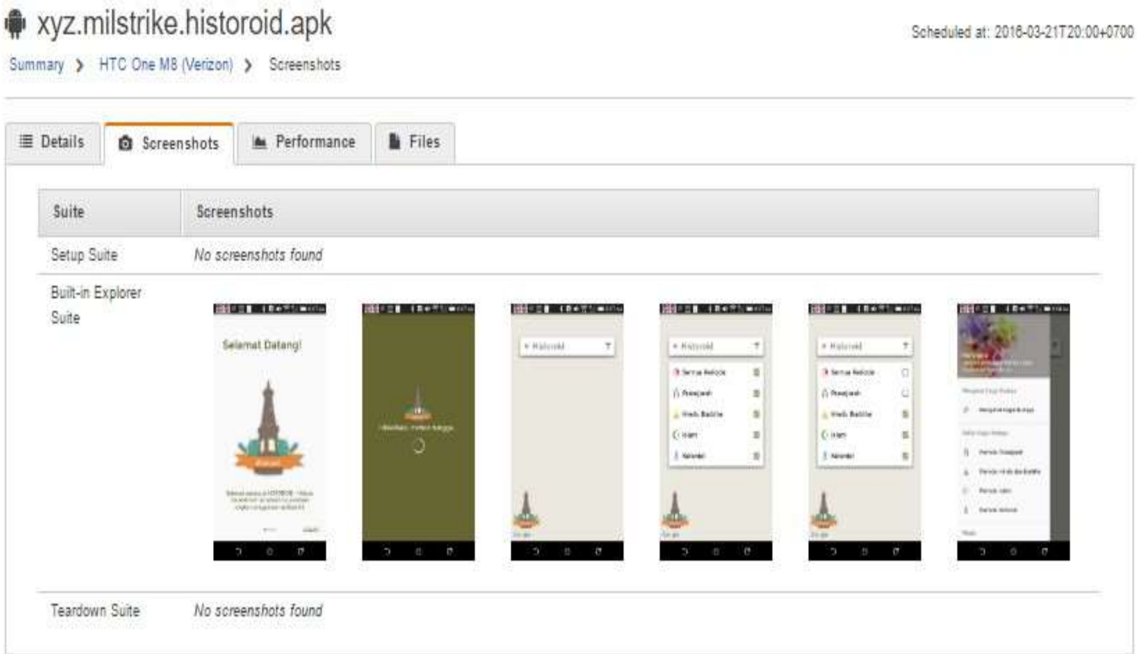

Figure 9. Compatibility testing on aspects of the screen dimension in the HTC One M8

D. Compatibility Testing

We conduct compatibility testing on the co-existence aspect using the AWS Device Farm automation testing tool. The app types used in this test include store applications, office, tools, multimedia, social media, and games. The app used in this test is Google PlayStore, Standard Messaging App, Contact App, Camera App, Google Keep App, Google Maps App, Facebook App, Office Suite App, Clash of Clans App, and Clash Royale App. These applications run together with the tested application on a single device. The test results are 100%, so it can be concluded that this application can run together with other applications without any error. Therefore, this application fulfills the compatibility in the co-existence aspect.

We conducted compatibility testing for the operating system aspect using the AWS Device Farm automation testing tool. The operating system used in this test is Android version 4.2.2 to Android version 6.0.1. There are eleven devices used for testing. The results of this test are 100%, which means the app is compatible with the operating system aspect. So it can be concluded that the app meets the compatibility in the operating system aspect.

Similar to two previous tests, we conducted compatibility testing in the device aspect using the same eleven devices. The test result is 100%. In addition, we also conducted compatibility testing in the device aspect using the compatibility module feature in the Google Play Developer Console. These test results show that the app is compatible with 9437 device types available in the Google Play Developer Console. These results indicate that the app is compatible across all test devices. Therefore, we can conclude that the app meets the compatibility in the device aspect.

Finally, we tested the screen dimension aspect compatibility using the same eleven devices. The results of this test are 100%. So it can be concluded that the app meets the compatibility in screen dimensions aspect.

E. Performance Efficiency Testing

We conducted a performance efficiency test that uses the same device as the previous compatibility test. We divided the test into two runs. One run for devices with Dalvik Virtual Machine, and another run with Android Run Time. We should divide the test into two runs because the device characteristics will affect the management of memory, CPU, and time behavior when a device runs the app. The results of the app performance efficiency test are as follows: (1) For devices with Dalvik Virtual Machine: CPU utilization average of 10.71%, memory utilization average of 33.11 MB, and time behavior average of 0.022 seconds, (2) For devices with Android Run Time: CPU utilization average of 9.918%, memory utilization average of 154.582 MB, and time behavior average of 0.020 seconds. Although, in general, from the test results, it can be concluded that the app uses a large number of resources, it can run well without experiencing a memory leak which can result in a force close and launch-fail.

Figure 10. Performance Efficiency Testing in HTC One M8

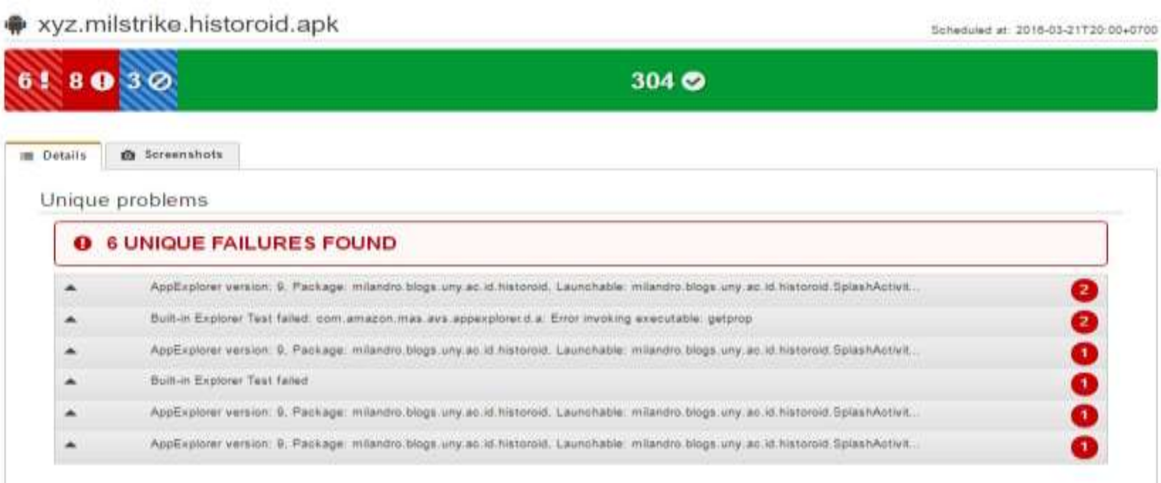

Figure 11. Overall Testing results in 321 devices

Figure 11 shows the overall testing result in 321 devices. From the test results in general, the app can run well on 304 devices, run with more resources on eight devices, fail on six devices, and skip on three out of a total of 321 test devices using AWS Device Farm Automation Testing Tools.

CONCLUSION

Based on the study results, it can be concluded that 1) A mobile app for mapping cultural heritage that can provide cultural heritage locations along with its descriptions, images, and videos has been successfully developed using Android and Google Maps technology. 2) The results of the app quality test on the functional suitability aspect are very good because all the app functions run 100%. The compatibility aspect is very good because the app can run well with other apps without any errors, run well on various Android operating system versions, and run well on various Android devices. In the aspect of performance efficiency, the result is very good because the app can run well on 312 of the 321 testing devices. The app can also run appropriately without a memory leak. In the Android devices with Dalvik Virtual Machine, the app have a time behavior average of 0.022 seconds/thread, use CPU average of 10.71%, and use memory average of 33.11 MB. Meanwhile, in the Android Run Time, the app has a time behavior average of 0.020 seconds/thread, a CPU average of 9.918%, and a memory average of 154.582 MB. So, in general, the quality of the app is very good. Based on the conclusions and findings of the studies, it is advisable to differentiate the results of testing applications based on Android with Dalvik Virtual Machine and Android Run Time.

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