SOUTHEAST ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

Volume 3, Issue 1, 2018
P-ISSN: 2672-2984
E-ISSN: 2672-2992
www.sajst.org

Issues and Challenges of Mobile Web Applications: A Systematic Literature Review

Ferdinand V. Dalisay
fvdalisay@psu.edu.ph
Pangasinan State University

Abstract - *The popularity of mobile handheld devices has led to a large variety of mobile applications being designed and developed for mobile operating system providers, such as Apple, Google, Blackberry and Microsoft. There are several types of mobile applications such as native, hybrid and web. Mobile web apps tend to solve several problems in native apps such as expensive multi-platform development and fragmentation. While these advantages were backed by some Google executives, a study conducted by ComScore - a leading American media measurement and analytics company, however, shows that user engagement on mobile web apps is significantly lower than that of the native apps. Thus, this paper aims to explore and discuss the underlying issues and challenges of progressive web applications or mobile web apps. This paper uses the Systematic Literature Review (SLR) method in undertaking a systematic literature review. Several issues were identified and heterogeneity of mobile devices and limited access to low level features are the most common issues that were discussed. In addition, there were nine (9) other issues that have been discovered.*

Keywords: issues and challenges, mobile web apps, progressive web apps

1 INTRODUCTION

Mobile handheld devices have been changing form and functionality over the last decade. It has changed from a limited-function device, with the primary function of making phone calls, to a multi-function device that becomes a media device for watching movies, playing games or as a remote control for home [1]. Before, some mobile devices were called “dumb” because they were either entirely email focused or sophisticated touch screens that could only be used with a stylus. Back then, some decent mobile devices were equipped with a browser capable of displaying anything more than simple text, links, and an image [2]. Over the last 5 years, mobile device technology has changed significantly, with devices and operating systems becoming more sophisticated and full of features. As a result, according to BBC News in 2012, In most developed countries, mobile phone penetration rates have reached over 100 percent per capita, with individuals often owning more than one mobile phone [3]. Google also announced that 500,000 new Android-based devices are registered every day [3]. Also, the IT industry analyst firm Gartner predicts that by 2022, 70 percent of software interactions will occur on mobile devices.

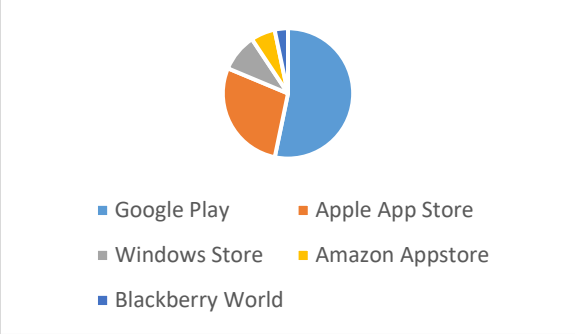
This popularity has led to a large variety of mobile applications being designed and developed for mobile operating system providers, such as Apple, Google, Blackberry and Microsoft. Amazon also offers an app store for the Android operating system. According to a statistics portal, and as seen in Figure 1, Google has the largest number of apps available for Android devices with an approximately 3.8 million apps in its Google Play store. Apple App Store has 2 million apps. Windows Store has 669 thousand apps. Amazon Appstore has 430

SOUTHEAST ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

Volume 3, Issue 1, 2018
P-ISSN: 2672-2984
E-ISSN: 2672-2992
www.sajst.org

thousand apps. Lastly, Blackberry World has 234,500 apps.

Figure 1: Number of apps available in leading app stores as of 1st quarter of 2018



Many mobile applications have been developed in critical areas such as transportation [4][5][6][7][8][9][10][11], healthcare [12][13][14][15][16][17][18][19], banking [20][21][22] and education [23][24][25][26][27][29]. In 2007, Apple planned to use open Web technologies in building 3rd-party applications. Apple even released tooling in its Dashboard project. However, for performance reasons, native applications took over applications written using Web technologies.

Web-based mobile applications tend to solve several problems. First, building a different app for each platform is very expensive if written in each native language. Second, web-based mobile application development can involve less effort since applications are built once and can be deployed on several mobile devices at once. Vic Gundotra, Vice President of Engineering at Google, said that Google is betting on Web Technology to solve the fragmentation issues in Android. Similarly, Alex Russell, a Google Senior Software Engineer Google, said that "Progressive Web Apps have a real-world advantage". However, a leading American media measurement and analytics company, ComScore, compared top 1000 mobile apps vs. top 1000 mobile app properties (web-based) to study user engagement. Result shows that user engagement on mobile web apps is significantly lower than that of the native apps (as seen in Figure 2).

Figure 2: User Engagement – Native Apps vs. Mobile Web Apps

This shows that while progressive web applications or mobile web apps solve several problems that are being encountered in native applications, there are underlying issues and challenges related to it. Thus, this paper aims to explore and discuss the underlying issues and challenges of progressive web applications or mobile web apps. This paper will only focus on mobile web apps (written in JavaScript, HTML5, PHP and other web technologies) and not on native nor hybrid apps.

The rest of the paper is organized as follows: section 2 discusses the methodology to be used. In section 3, results will be discussed. Finally, section 4 concludes the paper and presents the future work.

2 METHODOLOGY

This paper uses the Systematic Literature Review (SLR) method in undertaking a systematic literature review. By complying to the systematic procedure defined by the said research method, this paper can provide a more objective process in selecting relevant and note-worthy studies. The major steps in SLR include the following: (1) defining a research question, (2) search strategy

SOUTHEAST ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

Volume 3, Issue 1, 2018
P-ISSN: 2672-2984
E-ISSN: 2672-2992
www.sajst.org

for selecting studies and (3) management of studies.

Using the SLR methodology, the author should be able to define a research question that is anchored to purpose of the literature review. The author should also be able to plan for the search strategy and specify the steps needed. Lastly, the author should be able to manage the studies, filtering the irrelevant studies and selecting the pilot studies to be evaluated.

2.1 Defining a research question

This paper aims to identify the underlying issues and challenges of progressive web applications or mobile web apps and defining a research question is the initial step. The research question will be the basis for the search strategy and the selection of the pilot studies to be evaluated.

2.2 Planning a search strategy

The initial step in planning a search strategy is selecting the input data source. In this paper, ACM Digital Library will be used as a source for the relevant studies. ACM Digital Library has been chosen as a source because this is the most comprehensive database of full-text articles covering computing and information technology. The second step in our search strategy is to construct a query based on the research question. Keywords should be chosen carefully to maintain the proper balance between specificity and generality.

2.3 Managing the studies

After running the query in the ACM Digital Library, peer-reviewed journals will be obtained. But there is a need for each of the study to be assessed for its actual relevance through inclusion criteria. Table 1 shows the inclusion criteria.

Table 1: Inclusion Criteria

No.	Criterion	Description
1	It should be written in English.	There are some studies that are written in other language. They have provided English title and abstract so these papers will show up in the search results. Only studies written in English will be included.
2	It should be peer-reviewed.	To ensure the quality of this systematic literature review, only peer-reviewed studies will be included.
3	The publication date must not be earlier than 2013.	To ensure that only up-to-date energy-efficiency solutions are included, only studies that were published in the year 2013 onwards are selected.

To furtherly filter the researches and articles, abstract and conclusion of each study are carefully examined.

3 RESULTS AND DISCUSSION

This section will discuss the results of each step in the SLR methodology and later part will discuss the selected pilot studies according to the issue and challenge.

3.1 Research question defined

This paper aims to answer the following question: What are the underlying issues and challenges of progressive web applications or mobile web apps?

SOUTHEAST ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

Volume 3, Issue 1, 2018
P-ISSN: 2672-2984
E-ISSN: 2672-2992
www.sajst.org

3.2 Results of the search strategy

Keywords were constructed from the research question. These keywords will be used in the search query in ACM Digital Library. The following search query will be used: "*issues and challenges of progressive web applications or mobile web apps*". Table 2 shows the number of search results per source:

Table 2: Number of search results per source

Search query	Number of results (ACM Digital Library)
issues and challenges of progressive web applications or mobile web apps	505,037

3.3 Managing the studies

The search result for the first query has been furtherly refined by publication year (>= 2013). Table 3 shows the number of search results for the given query.

Table 3: Search result for the query with publication year is not earlier than 2013

Search query	Number of results (ACM Digital Library)
issues and challenges of progressive web applications or mobile web apps	154,843

To furtherly filter the results, advanced search feature has been used. The first where clause will be on the Title field that matches all (compared to matches any from the previous query) of the following words or phrases: "issues and challenges of progressive web applications or mobile web apps". The next where clause will be on the field of Publication Year, this is set to on or after (>=) 2013. The full query syntax is as follows:

> *"query": { acmdlTitle: (+issues +and +challenges +of +progressive +web +applications+or+mobile+web+apps)}*
>
> *"filter": {"publicationYear":{ "gte":2013 }}, {owners.owner=HOSTED}*

The above query resulted to fewer matches. Table 4 shows the number of search results from the query above.

Table 4: Search result for the query with publication year is not earlier than 2013 and query keywords matching the title

Search query	Number of results (ACM Digital Library)
issues and challenges of progressive web applications or mobile web apps	28

To furtherly filter the results and finally select the pilot studies, keywords, abstract and conclusion were read to verify and assess the paper's relevance to the research question. Table 5 shows the final list of 19 pilot studies to be evaluated.

SOUTHEAST ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

Volume 3, Issue 1, 2018
P-ISSN: 2672-2984
E-ISSN: 2672-2992
www.sajst.org

Table 5: Final list of researches with publication year

No.	Research Title	Publication Year
1	AppMobiCloud: Improving Mobile Web Applications by Mobile Cloud Convergence [29]	2013
2	Native or Web-Hybrid Apps? An Analysis of the Adequacy for Accessibility of Android Interface Components Used with Screen Readers [30]	2017
3	Beyond Native Apps: Web Technologies to the Rescue! [31]	2016
4	Challenges in Transition from Web to App [33]	2015
5	Towards Web Application Mobilization via Efficient Web Control Extraction [35]	2015
6	A Model-Based Method for Seamless Web and Mobile Experience [36]	2016
7	Accelerating the Mobile Web with Selective Offloading [37]	2013
8	Issues in Programmatically Designing User Interfaces in JavaScript [38]	2014
9	Cross-Platform Feature Matching for Web Applications [39]	2014
10	Issues on Developing a Location Aware Game for Mobile Browsers [40]	2016
11	The Long-Standing Privacy Debate: Mobile Websites Vs Mobile Apps [41]	2017
12	Coordinating Collaborative Interactions in Web-based Mobile Applications [42]	2015
13	Web-safe Fonts for Device-independent Mobile Web Applications [43]	2013
14	Raising Awareness of Mobile Widgets among Developers [44]	2013
15	Making Web Applications More Energy Efficient for OLED Smartphones [45]	2014
16	A Case Study of Application Development for Mobile and Location-Based Services [46]	2013
17	NativeWrap: Ad Hoc Smartphone Application Creation for End Users [48]	2014
18	Deconstructing the Energy Consumption of the Mobile Page Load [49]	2017
19	MobiTran: Tool Support for Refactoring PC Websites to Smart Phones [50]	2013

Additionally, the studies were categorized according to the issues and challenges they present. Table 5 shows the categorized studies:

Table 5: Categorized researches

No.	Issue and challenges	Studies
1	Limited computing capabilities of mobile device	[29][37]
2	heterogeneity of mobile devices	[29][36][43][46][40]
3	Accessibility problems	[30]

SOUTHEAST ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

Volume 3, Issue 1, 2018
P-ISSN: 2672-2984
E-ISSN: 2672-2992
www.sajst.org

4	Problem in handling heavy graphics	[31]
5	No full access to low level features (e.g. background services)	[31][42][44][46]
6	Distribution is not done via app stores	[31][44][33]
7	slow and expensive mobile network	[35][50][40]
8	Dynamic user interfaces	[38]
9	Cross-platform Consistency	[39]
10	Privacy concerns	[40][41][48]
11	Power consumption	[45][49]

From the categorized researches above, heterogeneity of mobile devices is the most common and prevailing issue of mobile web applications. Heterogeneity of mobile devices imposes challenges [29]. For example, performance of the same application could differ distinctively due to the wide heterogeneity of mobile devices. Mobile devices vary a lot in resource capabilities including CPU speeds, memory sizes, etc. Besides the variety of computing resources, these devices also vary in their software supports for Web applications, including browsers and JavaScript engines [29]. This can cause poor quality of app interaction or engagement on some other devices [36]. For example, a case study conducted by Granlund, et. Al. [46], some difficulties with location-based services were detected using the Opera browser, while lack of cross-platform functionality was found on Windows Phone's Internet Explorer version 6.0, this is due to limited HTML5 support. The same GPS problem with web based mobile games was documented by Kaplan, et. Al. [40]. Another result of heterogeneity of mobile devices is the inconsistent fonts support [43]. To solve this inconsistency, Chmielewski [43]'s paper provides font usage guidelines for the mobile web apps. The guidelines are based on results of a font availability detection experiment they have carried out on a wide range of diverse mobile devices.

Also related to inconsistencies, Choudhary, et. Al. [39] described the problem of inconsistent features being delivered between desktop and mobile versions of a web application. Whereas some of these differences are intentional, such as the addition of location-based features on mobile devices, others are not and can negatively affect the user experience [39].

Second most common issue is the limited access to low-level features of mobile devices. For mobile web applications, when compared to pure native applications, have limited ability to call device's low-level features such as background services [31]. For example, a case study conducted by Granlund, et. Al. [46], showed that a location-based mobile web app can have some problems providing proper scroll/touch functionality on Android versions earlier than 4.0 had, due to the inability to call native API. This issue also poses a limitation on the development of remote collaborative web-based applications [42]. It is also worth noting on this domain that the mobile widget (packaged web apps for mobile phones) recommendation by W3C did not receive proper attention among developer communities because it still lacks mobile OS support in the form of a native web run-time environment [44].

SOUTHEAST ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

Volume 3, Issue 1, 2018
P-ISSN: 2672-2984
E-ISSN: 2672-2992
www.sajst.org

The limited computing capabilities of mobile devices can also be seen as an issue [37] for some complex JavaScript mobile web applications [29]. Tests have been done and the results show that the performances of complex JavaScript applications on mobile devices are not always satisfying, compared with those on desktops and laptops [29]. For this issue, Wang, et. Al. [37] proposed a way to improve the performance of mobile web applications by offloading portions of the page load to significantly improve mobile page load time.

Also, mobile web applications, which are mostly written in HTML5 and JavaScript, struggle in handling heavy graphics [31], when compared to the games or applications created in some game engines like Unity.

For accessibility problems, most frequent problems were found in mobile web app components such as tables, headings and multimedia elements [30]. In the developer side, the lack of visualization when creating user interfaces through JavaScript imposes difficulty in the development process [38].

One more reason that turns off some developers in developing applications using Web technologies is that mobile web apps cannot be distributed via app stores [31][44]. This issue will hinder the application discovery via an app store [33].

Another prevailing challenge in mobile web apps is the slow and expensive mobile network. Mobile web applications are usually network bandwidth intensive and reliant and the slow mobile network can hamper good user experience and performance [35][40]. This led to some researchers [35][50] to develop mechanisms to offload or to control what portion of the page will be loaded to control the network traffic.

Privacy concerns should not also be taken lightly, for mobile browser games and applications, saving information and accessing user location can be much easier HTML5 without requiring the app to request permissions [40]. This was proven by the study of Papadopoulos, et. Al. [41]. Their results show that identifiers (coordinates, IMEI, Android ID, OS version, Build version, etc.) can easily be leaked on mobile browsers [41]. In this regard, Nadkarni, et. Al. [48], proposed a noble way to solve privacy issues. They proposed a mobile web app wrapper named NativeWrapper that has the following properties: isolated cookie store and phishing prevention.

Just like native apps, mobile web apps also face energy consumption issues especially for smartphones that use OLED displays [45]. OLED displays consume more energy when displaying light colors as opposed to dark colors. This is problematic as many popular mobile web applications use large light-colored backgrounds. To address this problem the researchers [45] developed an approach for automatically rewriting web applications so that they generate more energy efficient web pages. Other researchers [49] proposed a modeling approach to accurately estimate the energy consumption of any mobile web page load and deconstructs it into the energy contributions of individual components load activities. This can help the development team to determine which part can be optimized.

While there are many prevailing issues that impacts user engagement on mobile web apps, it is worth noting that some test results showed that the prototypes developed using web components were more compatible with accessibility criteria in the Web Content Accessibility Guidelines (WCAG 2.0) [30], which was developed through the W3C process.

4 CONCLUSION

Volume 3, Issue 1, 2018
P-ISSN: 2672-2984
E-ISSN: 2672-2992
www.sajst.org

In this paper, different issues and challenges of mobile web applications were explored and discussed. The papers were categorized according to the following issues: (1) Limited computing capabilities of mobile device, (2) heterogeneity of mobile devices, (3) Accessibility problems, (4) Problem in handling heavy graphics, (5) No full access to low level features (e.g. background services), (6) Distribution is not done via app stores, (7) slow and expensive mobile network, (8) Dynamic user interfaces, (9) Cross-platform Consistency, (10) Privacy concerns, and (11) Power consumption.

Heterogeneity of mobile devices is cited as the most common issue or challenge of mobile web application. This contradicts the notion that mobile web applications can solve fragmentation issues on some mobile devices. Second most common issue is the limited access to low level features of mobile devices. This hampers the development of complex mobile web applications that, for example, use background services. Also, the quality and performance of complex web applications and graphics intensive games can also be affected by the limited computational power of mobile devices. There were also issues discussed related to accessibility, non-distribution of apps via app stores, slow mobile network, dynamic user interfaces, cross-platform consistency, privacy and power consumption.

It is worth noting that while there are several issues and challenges being faced by mobile web apps, some test results showed that the prototypes developed using web components were more compatible with accessibility criteria in the Web Content Accessibility Guidelines (WCAG 2.0) [30], which was developed through the W3C process, than that of native apps.

REFERENCES

[1] Paul, S. (2010, August). Role of mobile handhelds in redefining how we work, live and experience the world around us: some challenges and opportunities. In Proceedings of the second ACM SIGCOMM workshop on Networking, systems, and applications on mobile handhelds (pp. 1-2). ACM.

[2] Charland, A., & Leroux, B. (2011). Mobile application development: web vs. native. Queue, 9(4), 20.

[3] Hoehle, H., & Venkatesh, V. (2015). Mobile Application Usability: Conceptualization and Instrument Development. Mis Quarterly, 39(2).

[4] Froehlich, J., Dillahunt, T., Klasnja, P., Mankoff, J., Consolvo, S., Harrison, B., & Landay, J. A. (2009, April). UbiGreen: investigating a mobile tool for tracking and supporting green transportation habits. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 1043-1052). ACM.

[5] Rayle, L., Shaheen, S., Chan, N., Dai, D., & Cervero, R. (2014). App-based, on-demand ride services: Comparing taxi and ridesourcing trips and user characteristics in san francisco university of california transportation center (uctc). University of California, Berkeley, United States Rogers, B.(2015) The social costs of Uber. James E. Beasley School of Law, Temple University, Philadelphia, United States.

[6] Wang, T., Cardone, G., Corradi, A., Torresani, L., & Campbell, A. T. (2012, February). WalkSafe: a pedestrian safety app for mobile phone users who walk and talk while crossing roads. In Proceedings of the twelfth workshop on mobile computing systems & applications (p. 5). ACM.

[7] Gavin, M., Ghosh, B., Pakrashi, V., Barton, J., O'Flynn, B., & Lawson, A. (2011). A cycle route planner mobile-app for Dublin city. In Irish Transportation Research Network Conference (ITRN2011), 31 Aug-1 Sep 2011, University College Cork, Cork, Ireland.. Irish Transportation Research Network.

[8] Stockx, T., Hecht, B., & Schöning, J. (2014, November). SubwayPS: towards smartphone

Volume 3, Issue 1, 2018
P-ISSN: 2672-2984
E-ISSN: 2672-2992
www.sajst.org

positioning in underground public transportation systems. In Proceedings of the 22nd ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems (pp. 93-102). ACM.

[9] Vieira, V., Salgado, A. C., Tedesco, P., Times, V., Ferraz, C., Huzita, E., ... & Steinmacher, I. (2012). The UbiBus project: Using context and ubiquitous computing to build advanced public transportation systems to support bus passengers. Anais do VIII Simpósio Brasileiro de Sistemas de Informação, 7.

[10] Navarro, K. F., Gay, V., Golliard, L., Johnston, B., Leijdekkers, P., Vaughan, E., ... & Williams, M. A. (2013, October). SocialCycle what can a mobile app do to encourage cycling?. In Local Computer Networks Workshops (LCN Workshops), 2013 IEEE 38th Conference on (pp. 24-30). IEEE.

[11] Broll, G., Cao, H., Ebben, P., Holleis, P., Jacobs, K., Koolwaaij, J., ... & Souville, B. (2012, December). Tripzoom: an app to improve your mobility behavior. In Proceedings of the 11th international conference on mobile and ubiquitous multimedia (p. 57). ACM.

[12] Boulos, M. N. K., Brewer, A. C., Karimkhani, C., Buller, D. B., & Dellavalle, R. P. (2014). Mobile medical and health apps: state of the art, concerns, regulatory control and certification. Online journal of public health informatics, 5(3), 229.

[13] Turner-McGrievy, G. M., Beets, M. W., Moore, J. B., Kaczynski, A. T., Barr-Anderson, D. J., & Tate, D. F. (2013). Comparison of traditional versus mobile app self-monitoring of physical activity and dietary intake among overweight adults participating in an mHealth weight loss program. Journal of the American Medical Informatics Association, 20(3), 513-518.

[14] Akinyele, J. A., Pagano, M. W., Green, M. D., Lehmann, C. U., Peterson, Z. N., & Rubin, A. D. (2011, October). Securing electronic medical records using attribute-based encryption on mobile devices. In Proceedings of the 1st ACM workshop on Security and privacy in smartphones and mobile devices (pp. 75-86). ACM.

[15] Aungst, T. D. (2013). Medical applications for pharmacists using mobile devices. Annals of Pharmacotherapy, 47(7-8), 1088-1095.

[16] Payne, K. F. B., Wharrad, H., & Watts, K. (2012). Smartphone and medical related App use among medical students and junior doctors in the United Kingdom (UK): a regional survey. BMC medical informatics and decision making, 12(1), 121.

[17] Aungst, T. D., Clauson, K. A., Misra, S., Lewis, T. L., & Husain, I. (2014). How to identify, assess and utilise mobile medical applications in clinical practice. International journal of clinical practice, 68(2), 155-162.

[18] Krebs, P., & Duncan, D. T. (2015). Health app use among US mobile phone owners: a national survey. JMIR mHealth and uHealth, 3(4).

[19] Semple, J. L., Sharpe, S., Murnaghan, M. L., Theodoropoulos, J., & Metcalfe, K. A. (2015). Using a mobile app for monitoring post-operative quality of recovery of patients at home: a feasibility study. JMIR mHealth and uHealth, 3(1).

[20] de Reuver, M., Verschuur, E., Nikayin, F., Cerpa, N., & Bouwman, H. (2015). Collective action for mobile payment platforms: A case study on collaboration issues between banks and telecom operators. Electronic Commerce Research and Applications, 14(5), 331-344.

[21] Bons, R. W., Alt, R., Lee, H. G., & Weber, B. (2012). Banking in the Internet and mobile era. Electronic Markets, 22(4), 197-202.

[22] Jones, W. (2014). M-commerce: Building the opportunity for banks. Journal of Payments Strategy & Systems, 8(3), 300-306.

[23] Chen, B., & Denoyelles, A. (2013). Exploring students' mobile learning practices in higher education. Educause Review, 7.

[24] Shuler, C. (2009). iLearn: A content analysis of the iTunes app Store's education section. onference P, 149.

Volume 3, Issue 1, 2018
P-ISSN: 2672-2984
E-ISSN: 2672-2992
www.sajst.org

[25] Rossing, J. P., Miller, W. M., Cecil, A. K., & Stamper, S. E. (2012). iLearning: The future of higher education? Student perceptions on learning with mobile tablets. Journal of the Scholarship of Teaching and Learning, 12(2), 1-26.

[26] Vázquez-Cano, E. (2014). Mobile distance learning with smartphones and apps in higher education. Educational Sciences: Theory and Practice, 14(4), 1505-1520.

[27] Mehdipour, Y., & Zerehkafi, H. (2013). Mobile learning for education: Benefits and challenges. International Journal of Computational Engineering Research, 3(6), 93-101.

[28] Hsu, Y. C., Rice, K., & Dawley, L. (2012). Empowering educators with Google's Android App Inventor: An online workshop in mobile app design. British Journal of Educational Technology, 43(1).

[29] Wang, X., Liu, X., Huang, G., & Liu, Y. (2013, October). Appmobicloud: improving mobile web applications by mobile-cloud convergence. In Proceedings of the 5th Asia-Pacific Symposium on Internetware (p. 14). ACM.

[30] Carvalho, L. P., & Freire, A. P. (2017, October). Native or Web-Hybrid Apps?: An Analysis of the Adequacy for Accessibility of Android Interface Components Used with Screen Readers. In Proceedings of the XVI Brazilian Symposium on Human Factors in Computing Systems (p. 38). ACM.

[31] Malavolta, I. (2016, October). Beyond native apps: web technologies to the rescue!(keynote). In Proceedings of the 1st International Workshop on Mobile Development (pp. 1-2). ACM.

[32] Srivastava, B. (2014, June). Composing web apis: State of the art and mobile implications (tutorial). In Proceedings of the 1st International Conference on Mobile Software Engineering and Systems (pp. 3-4). ACM.

[33] Kumar, R., Nivangune, A., & Joshi, P. (2015, October). Challenges in transition from web to app. In Proceedings of the 3rd International Workshop on Mobile Development Lifecycle (pp. 9-10). ACM.

[34] Balat, V. (2013, May). Client-server web applications widgets. In Proceedings of the 22nd International Conference on World Wide Web (pp. 19-22). ACM.

[35] Wang, S., Dou, W., Wu, G., Wang, J., Gao, C., Wei, J., & Huang, T. (2015, November). Towards Web Application Mobilization via Efficient Web Control Extraction. In Proceedings of the 7th Asia-Pacific Symposium on Internetware (pp. 21-29). ACM.

[36] Brambilla, M., Mauri, A., Franzago, M., & Muccini, H. (2016, October). A model-based method for seamless web and mobile experience. In Proceedings of the 1st International Workshop on Mobile Development (pp. 33-40). ACM.

[37] Wang, X. S., Shen, H., & Wetherall, D. (2013, August). Accelerating the mobile web with selective offloading. In Proceedings of the second ACM SIGCOMM workshop on Mobile cloud computing (pp. 45-50). ACM.

[38] Larkin, H. (2014, December). Issues in Programmatically Designing User Interfaces in JavaScript. In Proceedings of the 12th International Conference on Advances in Mobile Computing and Multimedia (pp. 72-76). ACM.

[39] Roy Choudhary, S., Prasad, M. R., & Orso, A. (2014, July). Cross-platform feature matching for web applications. In Proceedings of the 2014 International Symposium on Software Testing and Analysis (pp. 82-92). ACM.

[40] Kaplan, S., Ikonen, J., & Knutas, A. (2016, June). Issues on Developing a Location Aware Game for Mobile Browsers. In Proceedings of the 17th International Conference on Computer Systems and Technologies 2016 (pp. 129-136). ACM.

[41] Papadopoulos, E. P., Diamantaris, M., Papadopoulos, P., Petsas, T., Ioannidis, S., & Markatos, E. P. (2017, April). The long-standing privacy debate: Mobile websites vs mobile apps. In Proceedings of the 26th International Conference on World Wide Web (pp. 153-162). International World Wide Web Conferences Steering Committee.

SOUTHEAST ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

Volume 3, Issue 1, 2018
P-ISSN: 2672-2984
E-ISSN: 2672-2992
www.sajst.org

[42] Kambona, K., Hoste, L., Gonzalez Boix, E., & De Meuter, W. (2015, November). Coordinating Collaborative Interactions in Web-based Mobile Applications. In Proceedings of the 2015 International Conference on Interactive Tabletops & Surfaces (pp. 181-190). ACM.

[43] Chmielewski, J. (2013, December). Web-safe fonts for device-independent mobile web applications. In Proceedings of International Conference on Advances in Mobile Computing & Multimedia (p. 234). ACM.

[44] Al-Subaihin, A. A., & Al-Khalifa, H. S. (2013, July). Raising awareness of mobile widgets among developers. In Proceedings of the 18th ACM conference on Innovation and technology in computer science education (pp. 337-337). ACM.

[45] Li, D., Tran, A. H., & Halfond, W. G. (2014, May). Making web applications more energy efficient for OLED smartphones. In Proceedings of the 36th International Conference on Software Engineering (pp. 527-538). ACM.

[46] Granlund, D., Johansson, D., Andersson, K., & Brännström, R. (2013, December). A case study of application development for mobile and location-based services. In Proceedings of International Conference on Information Integration and Web-based Applications & Services (p. 658). ACM.

[47] Boulakbech, M., Messai, N., Sam, Y., & Devogele, T. (2017, April). A smart MobiWeb mashup trip planner tool. In Proceedings of the Symposium on Applied Computing (pp. 686-688). ACM.

[48] Nadkarni, A., Tendulkar, V., & Enck, W. (2014, July). NativeWrap: ad hoc smartphone application creation for end users. In Proceedings of the 2014 ACM conference on Security and privacy in wireless & mobile networks (pp. 13-24). ACM.

[49] Cao, Y., Nejati, J., Wajahat, M., Balasubramanian, A., & Gandhi, A. (2017). Deconstructing the Energy Consumption of the Mobile Page Load. Proceedings of the ACM on Measurement and Analysis of Computing Systems, 1(1), 6.

[50] Ma, Y., Fang, Y., Zhu, X., Liu, X., & Huang, G. (2013, December). MobiTran: tool support for refactoring PC websites to smart phones. In Proceedings Demo & Poster Track of ACM/IFIP/USENIX International Middleware Conference (p. 6). ACM.

[51] Lavoué, G., Chevalier, L., & Dupont, F. (2013, June). Streaming compressed 3D data on the web using JavaScript and WebGL. In Proceedings of the 18th international conference on 3D web technology (pp. 19-27). ACM.