



## Incorporating Heuristic Evaluation (HE) in the Evaluation of Visual Design of the Ecotourism Smartphone App

Tanalachimi Ganapathy, Mohd Kamal Othman\* & Abdulrazak Yahya Saleh

Faculty of Cognitive Sciences and Human Development,  
Universiti Malaysia Sarawak, Kota Samarahan, 94300, Malaysia

\*E-mail: omkamal@unimas.my

**Abstract.** Heuristic evaluation (HE) has proven to be important in developing computer systems but has not been incorporated into the development of ecotourism smartphone applications. This results in usability issues that significantly affect the user experience (UX), as discussed in the literature. This study reports the application of HE in the design and development of the Niranur Agro Farm (NAF) ecotourism smartphone app to improve the UX. Eight experts participated in this study, utilizing the SMART mobile usability heuristic developed for mobile applications and a severity rating scale to determine usability issues. The HE findings indicated 22 usability issues. One issue was rated 4 (catastrophic), four issues were rated 3 (major problem), twelve issues were rated 2 (minor problem), and five issues were rated 1 (cosmetic). Although there were some issues rated 4 and 3, most issues were considered minor (1 and 2 on the scale). The results indicated that it is crucial to incorporate HE into the design and development of the ecotourism smartphone app to minimize the usability issues faced by users. It further validated that utilizing a specific heuristic for smartphone apps ensures that all usability issues are correctly categorized and remedied.

**Keywords:** *ecotourism; heuristic evaluation; smartphone app; visual design; SMART heuristics; usability.*

### 1 Introduction and Background

The use of smartphone technology, in particular mobile applications to substitute other mobile-guide technology in ecotourism areas, could eliminate some of the problems experienced by tourists during their visits, such as reducing the learning curve so they do not have to focus on device operability but can concentrate on the information provided by the smartphone app. This is an important criterion in the design of multimedia content for mobile applications. It has been proposed that tourists who use a smartphone app while visiting a cultural heritage site are more immersed than those not equipped with a smartphone app [1]. Many touristic attractions have successfully encouraged the usage of mobile devices such as smartphone apps to enhance their visitors'

---

Received November 11<sup>th</sup>, 2020, Accepted for publication June 6<sup>th</sup>, 2021.

Copyright © 2020 Published by ITB Institute for Research and Community Services, ISSN: 2337-5795,

DOI: 10.5614/j.vad.2021.13.1.2

experience before, during, and after their visit, be it for travel purposes [2-4], tourism branding [5,6], destination management [7,8], or smart tourism [4,6,9-15] among others.

Dickinson et al. in [2] provided a good analysis of the usage of smartphone apps for tourism, in particular in the travel domain, while Gupta et al. in [16] identified the key factors in the adoption of smartphone apps in tourism, such as performance expectancy, perceived risk, perceived trust, and price savings. A smartphone app must be free from minor or major usability issues to provide a good user experience (UX).

The usability of mobile apps has been widely discussed in the literature using several different key criteria, for example: effectiveness [17,18], efficiency [19], satisfaction [19,20], learnability [21,22], memorability [20,23], and engagement [24,25]. Many of the smartphone apps that have been developed do not sufficiently emphasize certain aspects of design. The contents are not presented effectively to the user, which negatively impacts the user's interaction with the device [26,27]. Furthermore, some smartphone apps are designed in the same way as their Internet-based counterparts on web platforms, not considering the unique properties of the device (i.e. different screen sizes and resolutions, small input area) [26]. This contributes to information overload, too many site links and difficult navigation on mobile devices [28]. Therefore, users are confused and frustrated as the device does not conform to the main usability standards for smartphone apps, such as not using sufficiently large buttons to enable data entry, as the device layout is traded off for the accuracy of the information [29].

Usability evaluation focuses on the ease of use of mobile device features and determining whether users can execute their tasks successfully and efficiently. Dhoub et al. [30] analyzed various considerations from the literature in determining which usability evaluation methods (usability testing, heuristic evaluation, and cognitive walkthrough) are suitable for interactive adaptive systems. They further extended their results in the area of tourism in deciding the suitability of usability evaluation.

Usability evaluation methods are essential for system development to ensure its quality. HE is an evaluation method that focuses on evaluating an actual system or a prototype system carried out by experts. Although many previous studies have suggested that HE should be carried out by experts and not by actual users, in several studies, the evaluators were not only usability experts [31]. A detailed systematic analysis of related literature was conducted in [32]. It was discovered that of the 215 research articles analyzed, HE was used in articles, whereas user testing was used in 56 articles. In addition, it was found that 104 studies used a survey/questionnaire method. The analysis was conducted in all software

development domains. Therefore, it is important to examine the type of usability testing incorporated in developing a tourism application.

Recent research on tourism apps has mainly concentrated on usability testing (user evaluation) for users [33-38], while limited research efforts have applied HE in the design and development of smartphone apps [1,39]. Several researchers have demonstrated the benefits of HE in improving the UX [40-42]. Furthermore, no known research has adopted a specific heuristic for HE for ecotourism smartphone apps. Given the rapid proliferation of smartphone apps for tourism-related applications and the increasing importance of the UX, it is important to determine how this technology has been built to benefit visitors by ensuring that all relevant usability issues have been addressed before the app reaches the targeted users. This study had two objectives: (1) to concretize the need for incorporating HE into the design and development of ecotourism smartphone apps; (2) to determine the effectiveness of utilizing a specific heuristic for smartphones in HE to discover usability issues for ecotourism smartphone apps for further remediation.

## **2 Methodology**

### **2.1 Design and Development of Niranur Agro Farm (NAF) App**

This study used the Mobile Application Development Lifecycle (MADLC) as the framework for developing the Niranur Agro Farm (NAF) app. MADLC is designed for the development of a mobile application framework and comprises seven phases: (1) identification, (2) design, (3) development, (4) prototyping, (5) testing, (6) deployment, and (7) maintenance [43]. The researchers analyzed the current idea and design of the ecotourism-related smartphone app NAF in the first phase. Previous information on the architecture, design, features, and functions of ecotourism apps was gathered and used as a reference point for developing a new NAF app. In addition, the researchers made several visits (approximately two months) to the NAF to understand the issues/problems and how the smartphone app can be utilized to enhance the visitor's experience. An interview was held with the owner of the NAF to understand the activities and attractions of the NAF. This was important to ensure that the new NAF smartphone app would be fully utilized and positively impact the UX. In addition, a brief interview was conducted with five NAF visitors to understand their visitors' experiences and problems encountered during their visit. User comments and feedback were essential to ensure that the proposed NAF smartphone app would meet user expectations and specifications. It is important to involve users in the preliminary phase, as they may enhance the quality and

functionality of the smartphone app. The contents of the smartphone app, particularly detailed information about bees and the method of producing honey, were gathered through other methods, e.g., web searching, document analysis, and expert review.

The user requirements and specifications from the first phase and related details gathered for the smartphone app were translated into an initial design of the app. Use case design and evolutionary prototyping were involved in this phase. The use case design involved the business design and the user's interaction with the system [44], while evolutionary prototyping involved designing and developing low-fidelity prototypes. Sketches in the form of storyboards were developed based on the user requirements obtained in the first phase. Figure 1 shows the initial storyboard design sketches for the NAF app. Subsequently, this was transformed into a GUI design for a better design and functionality of the proposed app, as illustrated in Figure 2.

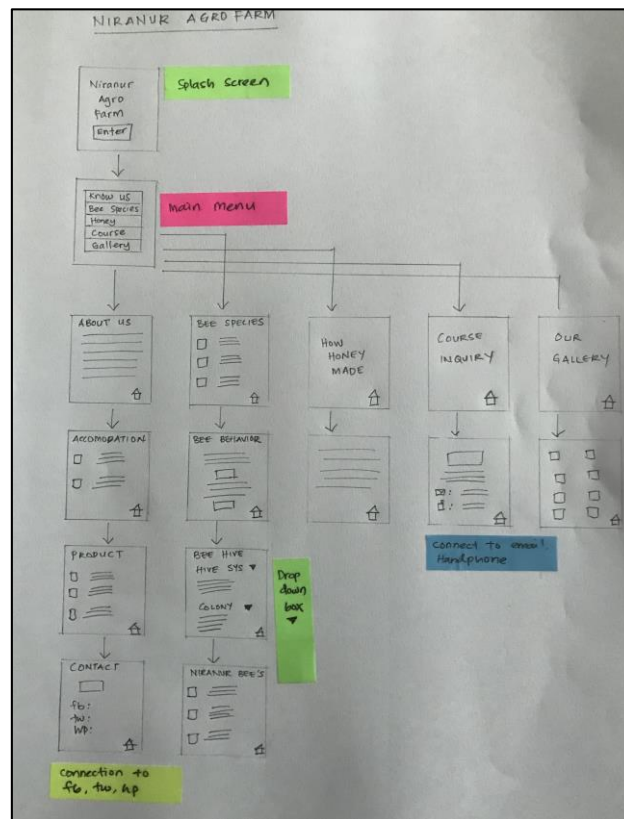
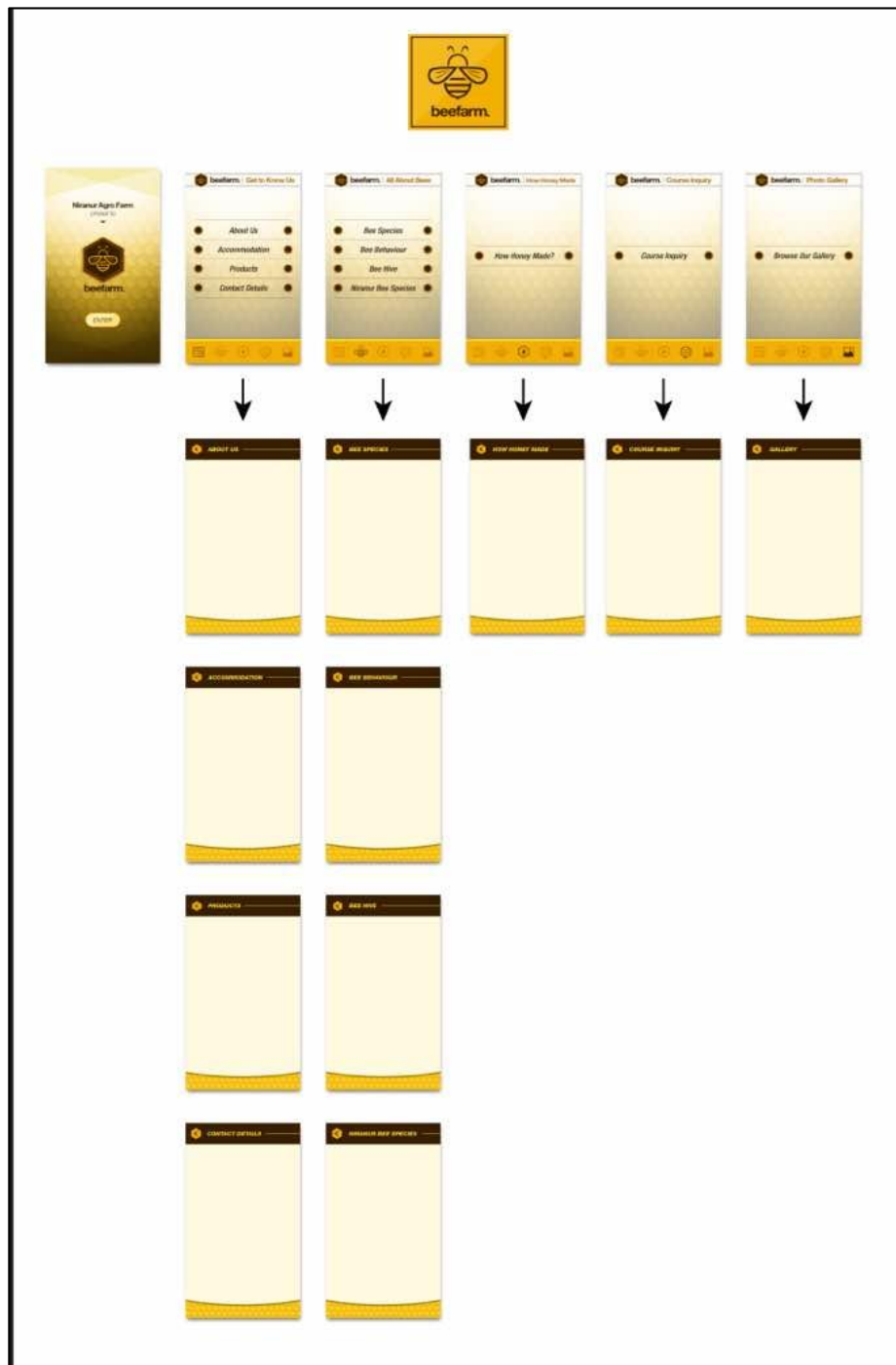


Figure 1 Storyboard sketches for the new NAF smartphone app.



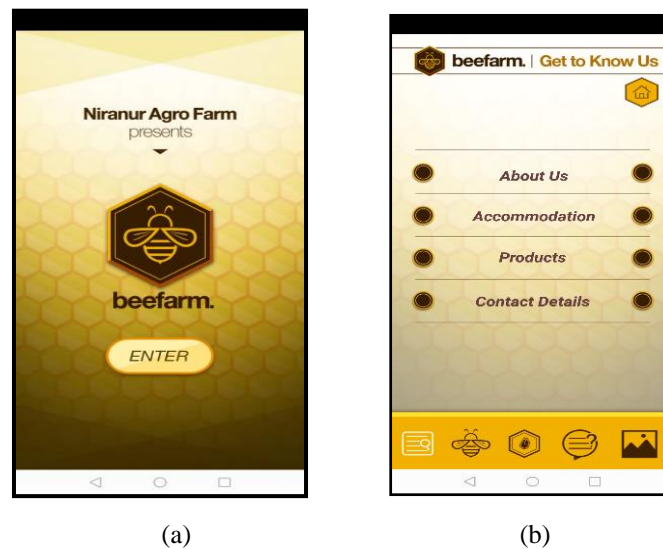
**Figure 2** GUI design for the NAF smartphone app.

The conceptual design was coded for the functional requirements (core functionalities) and user interface (UI) during the development and prototyping phases. Several prototypes were built and subsequently improved based on input from the development team. The prototypes were tested using emulators/simulators provided by the SDK. Some issues were addressed and changes were rendered so further work could be carried out. The assessment of the application in the testing phase usually requires a real user to test the usability of the application. In this study, HE was first performed in the development process with eight human-computer interaction (HCI) experts before the app was evaluated with real users. All usability issues identified at this phase were rectified before the app was deployed to users. The purpose of performing HE before undertaking product usability testing was to resolve the usability issues.

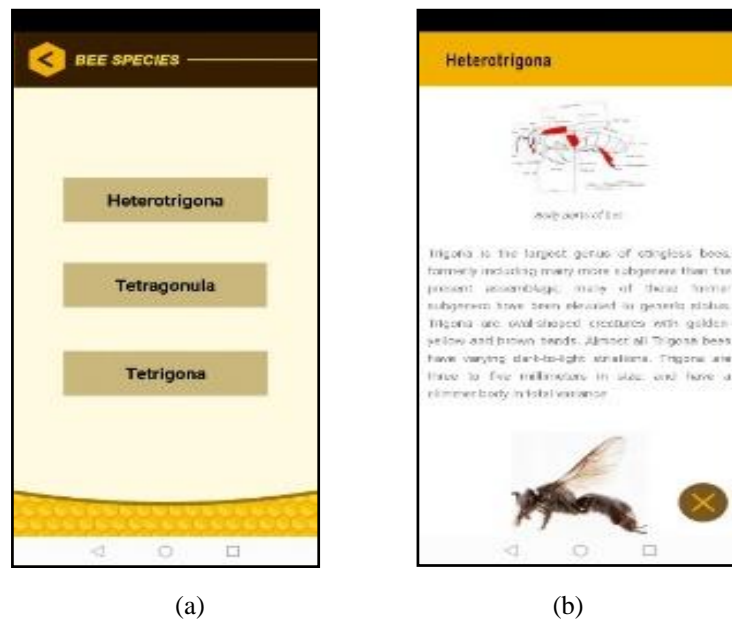
## 2.2 Materials

### 2.2.1 NAF Smartphone App

The user is taken to the front-page of the NAF and then routed to the menu page when the app is launched, as shown in Figures 3 (a) and 3 (b) respectively. Users can click on the menu to select the details they need, such as the farm itself, the bee species, the products, the honey-making process, and others. If the user clicks on the bee species icon, they will be directed to a screen showing different bee species (Figure 4 (a)) and subsequently information on each bee species (Figure 4 (b)).



**Figure 3** NAF front-page and menu page.



**Figure 4** Information provided to the user.

Traditionally, Nielsen's heuristics is used to identify issues with interfaces, but in this study, SMART heuristics as proposed by Joyce and Lilley [52] was used as a guideline. A SMART heuristic is an evaluation tool and a guideline for the design of mobile applications. Although Nielsen's heuristics is a well-established tool and has been extensively used on different types of interfaces, previous researches [1,53,54] have found that Nielsen's heuristics is not appropriate for smartphone apps. Currently, there are various types of specific heuristic techniques available, for example, TMD heuristics [55], SMASH heuristics [56], mobile interface checklist [57], MATch [58] and several other heuristics as mentioned by Salgado & Freire [59]. In this study, we used the SMART heuristics on a smartphone app based on the literature review.

The severity rating scale developed by Nielsen and Mack [60] was used to determine the severity of the usability issues identified. The scale consists of the following ratings: 0 = no usability at all, 1 = cosmetic problems (users will face minor problems; easily rectified); 2 = minor problems (users will face minor problems; should be fixed); 3 = major problems (users will have difficulty performing the task; should be fixed); 4 = catastrophic problems (users will have great difficulties in achieving their goals; must be fixed).

### 2.2.2 Participants

Eight experts, aged 20-35 years, consisting of 4 postgraduate HCI students and

four university HCI lecturers were recruited to participate in this study. They were recruited based on their experience and expertise in usability tests, having conducted at least 10 HE before this study.

### 2.2.3 Procedure

All participants recruited in this study were asked to evaluate the NAF smartphone app individually. The analysis protocol used was as follows:

1. Recruitment: 8 expert participants were recruited.
2. Briefing: The participants were briefed about their involvement and role in the study and the evaluation processes. They were informed about the purpose of the NAF app and how it will be used at NAF.
3. Informed consent: An informed consent form was provided to all participants, which they were asked to complete before starting HE. They were allowed to withdraw and were not financially rewarded for their participation.
4. Evaluation: Participants were loaned a Huawei 3i smartphone with the NAF app installed. They were also given a pen and paper to document any usability issues, using the severity rating scale. They were asked to familiarize themselves with the NAF app before they conducted the evaluation. Subsequently, they were asked to identify any issues using SMART heuristics.
5. Debriefing session: The researcher thanked the participants for their participation and contribution.

## 3 Results and Discussion

The participants identified 22 usability issues with the NAF app. Table 1 shows the usability issues and their average severity ratings. Many of the usability issues were categorized as minor usability issues (17 issues) and a total of 4 usability issues were categorized as major issues. Only one issue was rated 4 (catastrophic) by the participants. Table 2 summarizes the usability issues based on the different heuristics. The inconsistencies of buttons and menus were the only issue that participants categorized as catastrophic and required immediate changes.

Figures 5(a) and 5(b) illustrate the issues and their solutions. Issues rated 3 for their severity and required improvements were: inconsistency in page scrolling, no appropriate link to the exit menu, and no link to contact details. Figures 6(a) and 6(b) depict the problem and solution of not having an appropriate link to the exit menu. Figures 7(a) and 7(b) depict the problem and solution, but there is no link to the contact information.



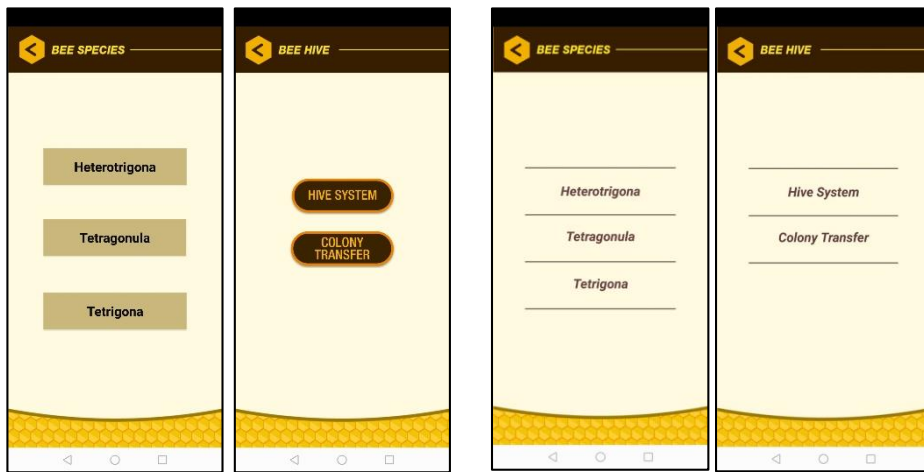
**Table 1** Usability issues.

<b>Issues</b>	<b>Average Rating</b>	<b>SMART Heuristic</b>
Inconsistent font size	2	S6
The paragraph is not aligned	2	S4
No link to contact details	3	S7
Name the image	1	S7
Inconsistent image	2	S9
Inappropriate link to the exit menu	3	S7
There is no auto tab	2	S4
The location map is not functioning	2	S11
Inconsistency in page scrolling	3	S6
Icons with text will work better	1	S11
Loading of the page too slow	2	S7
Inconsistent in a page exit	2	S6
The aesthetic design of the page is not appealing	2	S13
Inconsistency of buttons and menus	4	S13
Lack of icon use	3	S2
The proportion of photo size is not standardized	2	S2
Home button not relevant	1	S6
Grammatical error	1	S2
Word 'description' is not relevant	1	S6
Submenu button is not consistent	2	S2
Submenu is not relevant	2	S8
Inconsistent exit button for submenu	2	S2
<b>Total Usability Issues</b>		<b>22/22</b>

**Table 2** Total of usability Issues based on the SMART heuristic.

<b>SMART Heuristic and its description</b>	<b>Total</b>
<b>SMART 3:</b> Prevent errors where possible; assist user should an error occur	5
<b>SMART 4:</b> Display an overlay pointing out the main features when appropriate or requested	2
<b>SMART 6:</b> Design a visually pleasing interface	5
<b>SMART 7:</b> Intuitive interfaces make for easier user journeys	4
<b>SMART 8:</b> Design a clear navigable path to task completion	1
<b>SMART 9:</b> Allow configuration options and shortcuts	1
<b>SMART 11:</b> Facilitate easier input	2
<b>SMART 13:</b> Create aesthetic and identifiable icons	2
<b>Total</b>	<b>22</b>

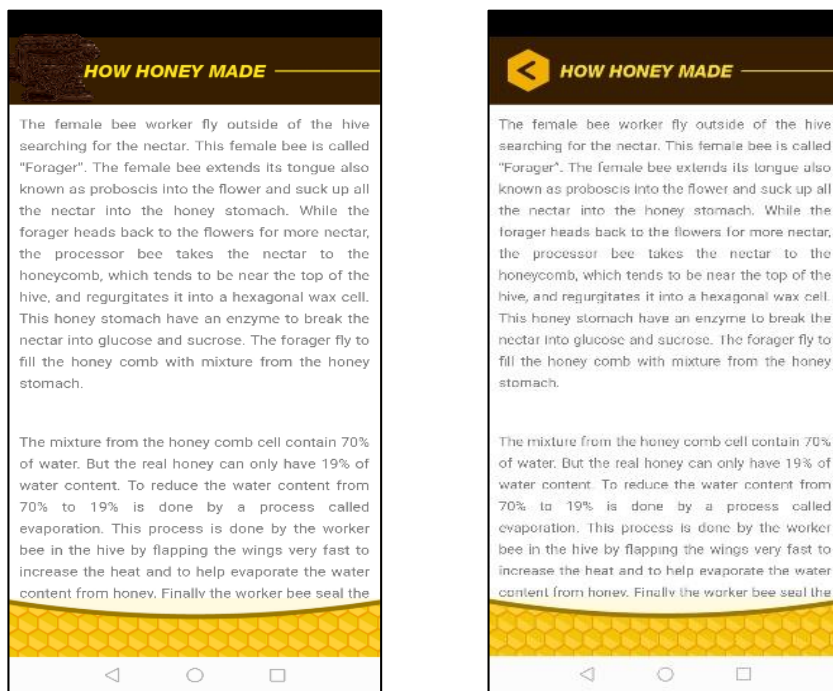
This study indicated that less than 0.05 per cent of the identified usability issues were rated as catastrophic, 18.7 per cent of the identified issues were rated as major and required changes, whereas in a previous study by Othman et al. [1], 19.35 per cent of identified usability issues were classified as catastrophic and 25.8 per cent of the usability issues were considered major. Although the percentage of catastrophic issues in this study was minimal, it



(a) issues

(b) solutions

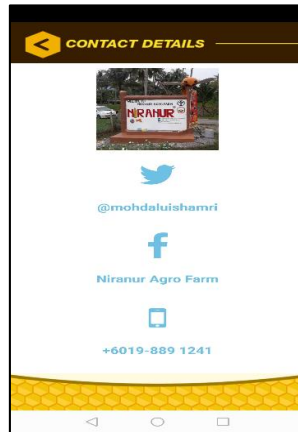
**Figure 5** Inconsistencies of menus and buttons.



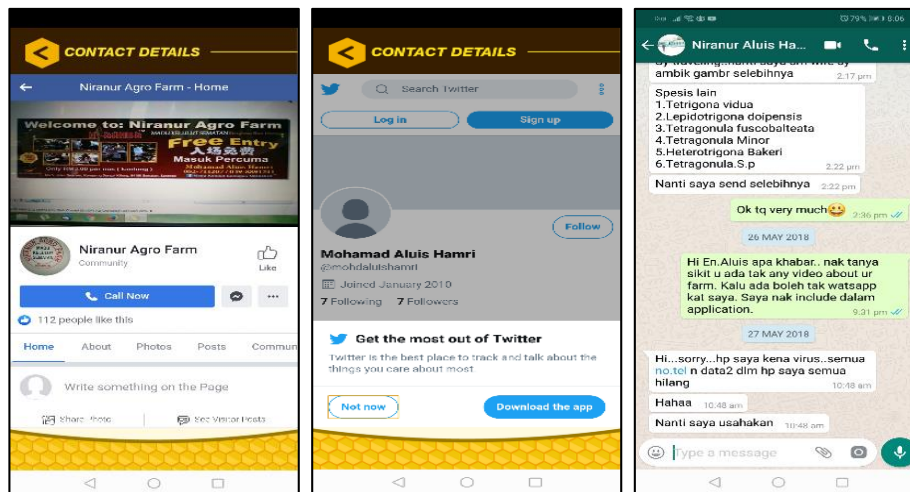
(a) issue – no back button

(b) solution with back button

**Figure 6** No appropriate link to the exit menu.



(a) issue – no link to contact details



(b) solution with contact details

**Figure 7** No link to contact details.

is crucial to rectify them before the smartphone app is deployed to users. Furthermore, the major issues identified in this study required attention from the developers before the app reached the potential users. Additionally, the results from this study echoed previous findings on usability issues with mobile technology, particularly inappropriate design content and navigation [42, 45]. Design content and navigation are important aspects of ecotourism applications as they potentially impact the UX.

The highlighted issues identified in this study suggest that HE must be integrated into the design and development of ecotourism smartphone apps to ensure that users do not have difficulties when using the app. Participants in this study rated most usability issues using SMART 3 and SMART 6 heuristics. The importance of using a specific heuristic technique for smartphone applications, such as SMART heuristics, greatly helps the participants correctly map usability issues and eliminate difficulties in mapping heuristics, as mentioned in previous research [1]. One of the drawbacks in applying HE in the design and development of a smartphone app is the availability of experts. A previous study indicated that the findings obtained from non-experts were not reliable and that HE requires experts in the field [46]. However, other studies have opted for the use of novice evaluators [47-51].

#### 4 Conclusion

In this study, we incorporated HE into the design and development of an ecotourism smartphone app. While most of the usability issues found in this study were minor, it did indicate that HE was indeed effective in identifying usability issues with the ecotourism smartphone app. This could potentially have a positive effect on the UX while using the app. Future studies will investigate whether positive or negative user experiences with the smartphone app at the ecotourism site were the result of the incorporation of HE in the design and development of the smartphone app. A parallel study on two different ecotourism sites should be conducted to compare the UX with the smartphone app built with or without HE integration.

#### References

- [1] Othman, M.K., Sulaiman, M.N.S. & Aman, S., *Heuristic Evaluation: Comparing Generic and Specific Usability Heuristics for Identification of Usability Problems in a Living Museum Mobile Guide App*, *Advances in Human-Computer Interaction*, 2018.
- [2] Dickinson, J. E., Ghali, K., Cherrett, T., Speed, C., Davies, N. & Norgate, S., *Tourism and the Smartphone App: Capabilities, Emerging Practice and Scope in the Travel Domain*. *Current Issues in Tourism*, **17**(1), pp. 84-101, 2014.
- [3] Höpken, W., Fuchs, M., Zanker, M. & Beer, T., *Context-based Adaptation of Mobile Applications in Tourism*. *Information Technology & Tourism*, **12**(2), pp. 175-195, 2010.
- [4] Huang, C.D., Goo, J., Nam, K. & Yoo, C.W., *Smart Tourism Technologies in Travel Planning: The Role of Exploration and Exploitation*. *Information & Management*, **54**(6), pp.757-770, 2017.

- [5] Dimitrovski, D., Joukes, V., Rachão, S. & Tibério, M. L., *Wine Tourism Apps as Wine Destination Branding Instruments: Content and Functionality Analysis*. Journal of Hospitality and Tourism Technology, **10** (2), pp. 136-152, 2019.
- [6] Kladou, S. & Mavragani, E., *Assessing Destination Image: An Online Marketing Approach and the Case of TripAdvisor*. Journal of Destination Marketing & Management, **4**(3), pp. 187-193, 2015.
- [7] Huang, Y.C., Backman, K.F., Backman, S.J. & Chang, L.L., *Exploring the Implications of Virtual Reality Technology in Tourism Marketing: An Integrated Research Framework*. International Journal of Tourism Research, **18**(2), pp. 116-128, 2016.
- [8] Li, S.C., Robinson, P. & Oriade, A., *Destination Marketing: The Use of Technology Since the Millennium*. Journal of Destination Marketing & Management, **6**(2), pp. 95-102, 2017.
- [9] Brandt, T., Bendler, J. & Neumann, D., *Social Media Analytics and Value Creation in Urban Smart Tourism Ecosystems*. Information & Management, **54**(6), pp. 703-713, 2017.
- [10] Chung, N., Tyan, I. & Han, H., *Enhancing the Smart Tourism Experience Through Geotag*. Information Systems Frontiers, **19**(4), pp. 731-742, 2017.
- [11] Kim, H.C. & Kim, Y.S., *Smart Tourism Information System using Location-Based Technology*. International Journal of Software Engineering and Its Applications, **10**(11), pp. 11-24, 2016.
- [12] Kim, D. & Kim, S., *The Role of Mobile Technology in Tourism: Patents, Articles, News, and Mobile Tour App Reviews*. Sustainability, **9**(11), 2082, 2017.
- [13] Um, T. & Chung, N., *Does Smart Tourism Technology Matter? Lessons From Three Smart Tourism Cities in South Korea*. Asia Pacific Journal of Tourism Research, pp.1-19, 2019.
- [14] Yoo, C.W. Goo, J., Huang, C.D., Nam, K. & Woo, M., *Improving Travel Decision Support Satisfaction with Smart Tourism Technologies: A Framework of Tourist Elaboration Likelihood and Self-Efficacy*. Technological Forecasting and Social Change, **123**, pp. 330-341, 2017.
- [15] Wang, X., Li, X.R., Zhen, F. & Zhang, J., *How Smart is Your Tourist Attraction?: Measuring Tourist Preferences of Smart Tourism Attractions Via A FCEM-AHP and IPA Approach*. Tourism Management, **54**, pp. 309-320, 2016.
- [16] Gupta, A., Dogra, N. & George, B., *What Determines Tourist Adoption of Smartphone Apps?*. Journal of Hospitality and Tourism Technology, **9**(1), pp 50-64, 2018.
- [17] Coorey, G.M., Neubeck, L., Mulley, J. & Redfern, J., *Effectiveness, Acceptability and Usefulness of Mobile Applications for Cardiovascular Disease Self-Management: Systematic Review with Meta-Synthesis of*

- Quantitative and Qualitative Data*. European Journal of Preventive Cardiology, **25**(5), pp. 505-521, 2018.
- [18] Thomas, R.L. & Fellowes, M.D., *Effectiveness of Mobile Apps in Teaching Field-Based Identification Skills*. Journal of Biological Education, **51**(2), 136-143, 2017.
- [19] Flood, D., Harrison, R., Iacob, C. & Duce, D., *Evaluating Mobile Applications: A Spreadsheet Case Study*. International Journal of Mobile Human Computer Interaction (IJMHCI), **4**(4), pp. 37-65, 2012.
- [20] Cata, T. & Martz, B., *Comparing Mobile Apps Usability Characteristics for Designers and Users*. Journal of International Technology and Information Management, **24**(4), 4. 2015
- [21] Leung, R., McGrenere, J. & Graf, P., *Age-Related Differences in The Initial Usability of Mobile Device Icons*. Behaviour & Information Technology, **30**(5), 629-642, 2011.
- [22] Stiles-Shields, C., Montague, E., Lattie, E.G., Schueller, S.M., Kwasny, M.J. & Mohr, D. C., *Exploring User Learnability and Learning Performance in an App for Depression: Usability Study*. JMIR Human Factors, **4**(3), e18, 2017.
- [23] Widodo, I. D., *Usability Testing for Android Based Application “Jogja Smart Tourism”*. In IOP Conference Series: Materials Science and Engineering. **215** (1), pp. 012031, 2017.
- [24] Kim, E., Lin, J.S. & Sung, Y., *To App or Not to App: Engaging Consumers Via Branded Mobile Apps*. Journal of Interactive Advertising, **13**(1), pp. 53-65, 2013.
- [25] Dinner, I.M., Van Heerde, H.J. & Neslin, S.A., *Driving Online and Offline Sales: The Cross-Channel Effects of Traditional, Online Display, and Paid Search Advertising*. Journal of Marketing Research, **50**(5), pp. 527-545. 2013.
- [26] Forrester Research., *How Mature is Your Mobile Strategy?*, [http://blogs.forrester.com/thomas\\_husson/10-10-19](http://blogs.forrester.com/thomas_husson/10-10-19), (15 March 2012)
- [27] Youens, R., *7 Habits of Highly Effective Apps*, GIGACOM, [://gigaom.com/2011/07/16/7-habits-of-highly-effective-apps/](http://gigaom.com/2011/07/16/7-habits-of-highly-effective-apps/), (24 March 2012).
- [28] Adipat, B., Zhang, D. & Zhou, L., *The Effects of Tree-View Based Presentation Adaptation on Mobile Web Browsing*. MIS Quarterly, pp. 99-121, 2011.
- [29] Deloitte., *So Many Apps – So Little to Download*, <http://www.mondaq.com/x/192692/IT+internet/So+Many+Apps+So+Little+To+Download>, (15 March 2012)
- [30] Dhouib, A., Assila, A., Trabelsi, A., Kolski, C. & Neji, M., *Factors Affecting the Choice of Usability Evaluation Methods for Interactive Adaptive Systems*. In International Conference on Human-Centred Software Engineering, pp. 270-282, 2018.

- [31] Salgado, A.D.L., *Adaptations to the Heuristic Evaluation (HE) Method for Novice Evaluators*, PhD dissertation, Universidade de São Paulo, Sao Carlos, 2017.
- [32] Paz, F. & Pow-Sang, J. A., *A Systematic Mapping Review of Usability Evaluation Methods for Software Development Process*. International Journal of Software Engineering and Its Applications, **10**(1), pp. 165-178, 2016.
- [33] Tarantino, E. De Falco, I., & Scafuri, U., *A Mobile Personalized Tourist Guide and Its User Evaluation*. Information Technology & Tourism, **21**(3), pp. 413-455, 2019.
- [34] Stangl, B., Ukpabi, D.C. & Park, S., *Augmented Reality Applications: The Impact of Usability and Emotional Perceptions on Tourists' App Experiences*. In Information and Communication Technologies in Tourism 2020, pp. 181-191, 2020.
- [35] Fang, Y.M. & Lin, C., *The Usability Testing of VR Interface for Tourism Apps*. Applied Sciences, **9**(16), pp. 3215, 2019.
- [36] Gavalas, D., Kasapakis, V., Konstantopoulos, C., Pantziou, G. & Vathis, N., *Scenic Route Planning for Tourists*. Personal and Ubiquitous Computing, **21**(1), pp. 137-155, 2017.
- [37] Anacleto, R., Figueiredo, L., Almeida, A. & Novais, P., *Mobile Application to Provide Personalized Sightseeing Tours*. Journal of Network and Computer Applications, **41**, pp. 56-64, 2014.
- [38] Umanets, A., Ferreira, A. & Leite, N., *Guideme—A Tourist Guide with A Recommender System and Social Interaction*. Procedia Technology, **17**, pp. 407-414, 2014.
- [39] Renzi, A.B., Almeida, O. & Cesar, M., *User Experience Interaction in Cross-Channel Systems: Comparing Heuristic Evaluations*. In International Conference on Applied Human Factors and Ergonomics, pp. 547-558, 2019.
- [40] Tehrani, S.E.M., Zainuddin, N.M.M. & Takavar, T., *Heuristic Evaluation for Virtual Museum on Smartphone*. In 2014 3rd International Conference on User Science and Engineering (i-USEr), pp. 227-231, 2014.
- [41] Hausmann, A., Weuster, L. & Nouri-Fritsche, N., *Making Heritadge Accessible: Usage and Benefits of Web-based Applications in Cultural Tourism*. International Journal of Cultural and Digital Tourism, **2**(1), pp. 19-30, 2015.
- [42] Chen, W., *Historical Oslo on A Handheld Device—A Mobile Augmented Reality Application*. Procedia Computer Science, **35**, pp. 979-985, 2014.
- [43] Vithani, T. & Kumar, A., *Modeling the Mobile Application Development Lifecycle*. In Proceedings of the International MultiConference of Engineers and Computer Scientists, **1**, pp. 596-600, 2014.

- [44] Choudary, S.A.R., Dhupia, B.S., Litayem, N. & Jaafar, B., *Investigating user Requirements for Mobile Educational App Impact of Requirement Gathering on Software Development*. **4**(3), pp. 1-9. 2015.
- [45] Helyar, V. *Usability Issues and User Perceptions of A 1st Generation WAP Service*, <http://usability.serco.com/research/research.htm#research> (20 June 2018).
- [46] Desurvire, H., Lawrence, D. & Atwood, M., *Empiricism Versus Judgement: Comparing User Interface Evaluation Methods on A New Telephone-Based Interface*. ACM SIGCHI Bulletin, **23**(4), pp. 58-59, 1991.
- [47] Botella, F., Alarcon, E. & Peñalver, A., *A New Proposal for Improving Heuristic Evaluation Reports Performed by Novice Evaluators*. In Proceedings of the 2013 Chilean Conference on Human-Computer Interaction, pp. 72-75, 2013.
- [48] Borys, M. & Laskowski, M., *Expert vs Novice Evaluators*. In Proceedings of the 16th International Conference on Enterprise Information Systems, **3**, pp. 144-149, 2014.
- [49] Jeffries, R. & Desurvire, H., *Usability Testing Vs. Heuristic Evaluation: Was There a Contest?*. ACM SIGCHI Bulletin, **24**(4), pp. 39-41, 1992.
- [50] MacFARLANE, S. & Pasiali, A., *Adapting the Heuristic Evaluation Method for Use with Children*. In Workshop on Child Computer Interaction: Methodological Research, pp. 28-31, 2005.
- [51] Wodike, O.A., Sim, G. & Horton, M., *Empowering Teenagers to Perform a Heuristic Evaluation of a Game*. In Proceedings of the 28th International BCS Human Computer Interaction Conference (HCI 2014), **28**, pp. 353-358, 2014.
- [52] Joyce, G. & Lilley, M., *Towards the Development of Usability Heuristics for Native Smartphone Mobile Applications*. In International Conference of Design, User Experience, and Usability, pp. 465-474, 2014.
- [53] Joyce, G., Lilley, M., Barker, T. & Jefferies, A., *Smartphone application usability evaluation: the applicability of traditional heuristics*. In International Conference of Design, User Experience, and Usability, pp. 541-550, 2015.
- [54] Joyce, G., Lilley, M., Barker, T. & Jefferies, A., *Evaluating the Impact of Changing Contexts on Mobile Application Usability Within Agile Environments*. In 2016 Future Technologies Conference (FTC), pp. 476-480, 2016.
- [55] Inostroza, R., Rusu, C., Roncagliolo, S. & Rusu, V., *Usability Heuristics for Touchscreen-Based Mobile Devices: Update*. In Proceedings of the 2013 Chilean Conference on Human-Computer Interaction, pp. 24-29, 2013.



- [56] Inostroza, R., Rusu, C., Roncagliolo, S., Rusu, V. & Collazos, C. A., *Developing SMASH: A set of SMARtphone's uSability Heuristics*. *Computer Standards & Interfaces*, **43**, pp. 40-52, 2016.
- [57] Bertini, E., Gabrielli, S., Kimani, S., Catarci, T. & Santucci, G., *Appropriating and Assessing Heuristics for Mobile Computing*. In *Proceedings of the working conference on Advanced visual interfaces*, pp. 119-126, 2006.
- [58] Salazar, L.H.A., Lacerda, T., Nunes, J. V. & von Wangenheim, C. G., *A Systematic Literature Review on Usability Heuristics for Mobile Phones*. *International Journal of Mobile Human Computer Interaction (IJMHCI)*, **5**(2), pp, 50-61, 2013.
- [59] de Lima Salgado, A. & Freire, A. P., *Heuristic Evaluation of Mobile Usability: A Mapping Study*. In *International Conference on Human-Computer Interaction*, pp. 178-188, 2014.
- [60] Nielsen, J., *Usability inspection methods*. In *Conference companion on Human factors in computing systems*, pp. 413-414, 1994