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DEVELOPMENT OF A WEB BASED VIRTUAL FOREST ENVIRONMENT TO INCREASE THREATENED PLANT SPECIES AWARENESS

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ABSTRACT

This paper reports on the development of a web based virtual forest environment to raise the awareness of threatened plant species in particular for the family of Dipterocarpaceae. Tropical forests in Malaysia consists of unique ecosystems which are home to flora and fauna including the threatened plant species that are listed in the Red List by the Forest Research Institute of Malaysia. However, the lack of awareness on the threatened plant species somehow can jeopardise on the effort on conservation of the forest. A web based utilizing virtual environment were developed that focussed on threatened plant species. User experiments were conducted to evaluate the user acceptance on the developed application. 30 participants were divided into two groups, brochures and web version. Results showed that participants who completed the experiments with web based virtual environment increased their level of awareness as compared to the usage of conventional brochures on threatened plant species.

Keywords: Technology Intervention; Virtual Environment; Tropical rainforest species; Threatened Plant Species.

INTRODUCTION

Tropical rainforests in Malaysia consist of an estimated 8,300 species of vascular plants in Peninsular Malaysia, with another 12,000 in the East (Saw et al. 2010). Social-economic development has a massive influence on the biological diversity (Chua, Suhaida & Aslina 2012). To achieve a balance between conservation and development, priorities appropriate to the present and future needs of the country have to be identified and integrated into policy development, decision making negotiations and implementation. The Malaysian Malaysia Policy in Biological Diversity formulated in 1998, sets Malaysia's agenda and direction for the country to implement strategies and action plans for the conversation and sustainable utilisation of its biological diversity.

Abiding by the policy, Malaysia Plant Red List (Chua et al. 2010) had been developed by Forest Research Institute Malaysia (FRIM), listing the critically threatened plants in tropical rainforest in Peninsular Malaysia in particular the family of Dipterocarpaceae to assess and monitor the conservation of the rare and threatened plants. The family of Dipterocarpaceae has the largest population in the tropical rainforest of Malaysia and the population has decreased from year to year (Chua, Suhaida & Aslina 2012). Therefore, efforts has been made to conserve the threatened plant species (Saw et al. 2010) by FRIM and other agencies. Some of the habitats of the species has been restricted and not allowed to be visited by the public to protect the species. However, the implication of this action is badly affected. It decreases the awareness of threatened plant species as the public cannot enjoy the beauty of the nature of the habitat.

Therefore, the awareness of this matter has to be increased to protect the species and land use status in the future and this effort includes increasing awareness to the public and stakeholders (Chua, Suhaida & Aslina 2012). According to Wright & Burnham (2009), virtual environment is engaging and have potential to raise awareness in their related study subjects. Hence, we conducted this study to use web on the internet and a virtual forest to raise the awareness of threatened plant species in Malaysia.

VIRTUAL FOREST ENVIRONMENT AND AWARENESS

Awareness is important to increase the conservation activities for threatened plant species (Chua, Suhaida & Aslina 2012). Through a technological approach, especially with the internet, it can be a good mechanism to increase the awareness of nature and forestry issue (Lineman et al. 2014; Le Nghiem et al. 2016). In addition to that, the use of online and other digital media such as documentaries, educational portals, virtual environments, e-museums and e-learning can distribute the information to the public and increase awareness on the focus subject (Sypsas, Tsitsanoudis – Mallidis & Dromantiene 2013).

Virtual environments have been a successful medium to raise awareness in many studies. Bruno et al. (2017) had developed a comprehensive integration of digital technologies including a virtual underwater environment which was impossible to be reached by most of people in the world in order to raise awareness on his subject matter, while Wright & Burnham (2009) had developed a virtual environment for the awareness of cyberbullying. The awareness of heritage also has been increased by using virtual environment technology in Aggour (2017)'s and Nazrita & Nazlena (2018)'s studies.

There are a few studies focused on using a virtual environment to motivate certain human behaviours towards the directions of human well-being (Herrera et al. 2018; Ahn 2015). Jaafar & Mckenzie (2010), have focused on Dempster-Shafer's Theory of Evidence to present a solution for behavioural animation of autonomous virtual agent navigation in virtual environments. Tengku Siti Meriam et al. (2016) used a virtual environment to develop a model of user interaction design in a virtual museum and Yuwaldi Away & Abdul Rahman (2001) on building the prototype on effective interactive display on a virtual 3D environment.

Several studies have been held on the technology usage of the virtual environment and forestry together by developing a virtual forest. A virtual forest is a set of omnidirectional images or videos taken in a forest using a digital camera with an omnidirectional vision sensor (Abe et al. 2005). Among the studies, Fabrika (2018) and Qi et al. (2004), have conducted a study on using a virtual forest environment for collaborative forest management. Abe et al. (2005), used a virtual forest to comply with the forest education needs.

A few models or frameworks of designing virtual environment have been built. Fencott (1999); Gabbard, Hix & Swan (1999); Di Gironimo, Lanzotti & Vanacore (2006); Tengku Siti Meriam et al. (2016); Nazrita & Nazlena (2018) have developed their own model of designing a virtual environment. Comparing all of these studies, only Nazrita and Nazlena (2018), created a conceptual framework for designing the virtual environment to increase the awareness of their subject focus.

There have been no studies on developing a virtual forest environment to increase awareness on forestry or threatened plant species. The plant species in this study are rarely found in Malaysia. Some of the species such as *Shorea resinosa* (Meranti Belang) are not permitted to be viewed physically by the public. Therefore, MyRedList, a web based virtual forest environment had been built in this study to give easier access for the users to 'feel' the habitat of the plant species rather than physically locating users into the habitat of the species. The usage of MyRedList has the potential to increase awareness of users on threatened plant species.

METHODOLOGY

The development of the prototype and the application of MyRedList is based on a conceptual framework for designing the virtual environment to increase awareness by Nazrita and Nazlena (2018). Therefore, an experiment needed to been held to show evidence whether using the web based virtual forest environment (MyRedList) developed in this study using the conceptual framework for designing a virtual environment could raise awareness for the conservation activities of threatened plant species in Malaysia. The experiment was a between-participants design in which the participants were divided into two groups: using virtual environment (Group A) and using printed brochures (Group B). Data has been collected using questionnaires for each group.

VIRTUAL ENVIRONMENT

A responsive web application with virtual forest environment called MyRedList has been used in the experiment. The participants used smartphone Samsung S7 Edge running in Android 4.4with a Chrome Web browser app and Youtube app preinstalled. Both apps needed to be used to access MyRedList.

MyRedList has two components: a web based information component and a virtual environment component. The web based information component was developed using Adobe Coldfusion 2016 with Microsoft SQL Server Management Studio 2014 as the database. It has been developed on Windows 10 Pro and with Internet Information Services (IIS) as the web server. It also has been linked with MyBIS (Ministry of Water Land and Natural Resources 2016) and FRIM's Official website in the Colours of FRIM columns (Forest Research Institute Malaysia 2018) for the detail information of each plants.

The web application component can be viewed either on computer, laptop, tablet or smartphone because it had been built with responsive mode as shown in Figure 1.

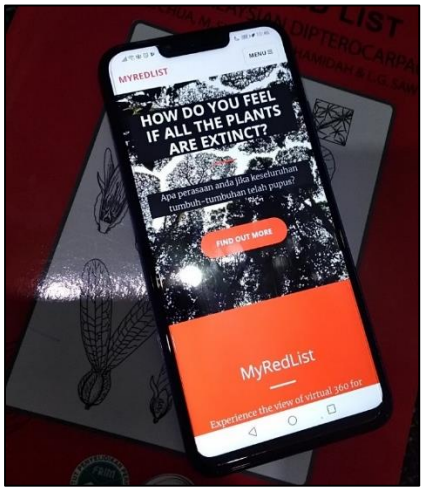

FIGURE 1. MyRedList in responsive mode on smartphone

The virtual environment component was built using Samsung 360 Gear Manager, Samsung Gear 360 Camera and YouTube as the launcher. Two species are captured with the camera in this pilot study and they are listed in Malaysia Plant Red List (Chua et al. 2010).

According to Bruno et al. (2017), their application that had virtual environment technology had increased awareness by providing immersive technologies using off-the-shelf Head Mounted Device (HMD) and some information about their focus subject.

The virtual environment component is suitable to be used with the smartphone together with the HMD with sound system. We chose the HMD with sound system to increase the immersive experiences of the virtual environment. These technologies is very useful to enhance immersiveness in the virtual environment (Fabrika 2018).

The general information of the threatened plants is included in the database to be viewed by the participants. Two species has been chosen for this pilot study and they are *Vatica yeechongii* (Resak Daun Panjang) and *Shorea resinosa* (Meranti Belang).

THREATENED PLANT SPECIES SELECTION

The forest species involved in this study are from the family of Dipterocarpaceae. The family of Dipterocarpaceae is the largest family affected by the decrease of Malaysia's tropical rainforest and some species in the Dipterocarpaceae family have been identified as the threatened plant in Peninsular Malaysia (Chua et al. 2010). There are several genera listed in the Dipterocarpaceae family in Malaysia Plant Red List as shown in Table 1. In this pilot study, we chose the species from genus *Vatica* and *Shorea*. Among the genus *Vatica* and *Shorea*, *Vatica yeechongii* (Resak Daun Panjang) is listed as Critically Endangered and *Shorea resinosa* (Meranti Belang) as Vulnerable (Chua et al. 2010).

TABLE 1. The genus in Malaysia Plant Red List

Genus	**Total Species**
Anisoptera	6
Cotylelobium	2
Dipterocarpus	32
Dryobalanops	3
Hopea	33
Neobalanocarpus	1
Parashorea	3
Shorea	62
Vatica	22
Total	**164**

The species selection had been suggested by experts in the related field in FRIM. The expert had published a few papers involving threatened plant species and the species was suggested due to the location of its habitat which could not be viewed physically by the public without permission. Since the threatened plants are hard to find, we focused on species that were available in Klang Valey, Malaysia, as we needed to record the 360 virtual video for the species' habitat. Both species, *Vatica yeechongii* and *Shorea resinosa* are among plants available in the Klang Valley area. Figure 2 shows the view of the application displaying the information of the two species mentioned above.

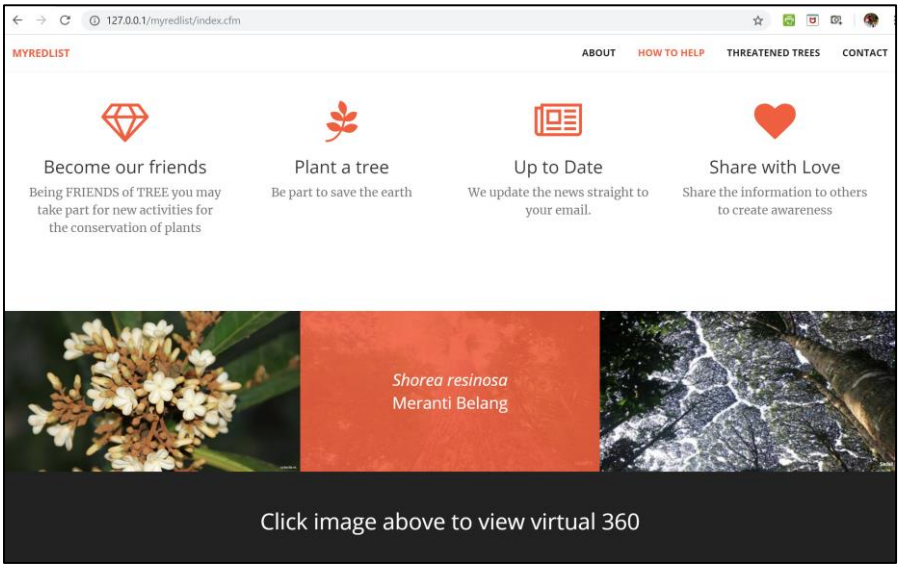

FIGURE 2. MyRedList application listed the species in the pilot study.

QUESTIONNAIRE

There were two sets of questionnaires used for the pre-test and post-test. Set A questionnaire was for questions about the threatened plant species for participants using brochures. Set B was a questionnaire on the same topic for participants using MyRedList. The questionnaire was adapted from Abe et al. (2005); Korićanin et al. (2014). The questions included demographic questions and questions related to forest conservation in Malaysia including threatened plant species.

PARTICIPANTS

There were 30 participants (12 males and 18 females) that were involved in the experiment whom were recruited using convenient and snowball sampling methods. The convenience sample selected by the respondents was selected based on their time and willingness to participate in this study. Some of the respondents had suggested to other respondents to agree to participate in this study (snowball sampling). The participants' age ranged between 25 to 45 years old (M = 38.5, SD = 5.11). Only 13.3% of the participants were not working or were housewives and the rest were professionals (33.3%), executives (26.7%) and entrepreneurs (26.7%). 53.3% percent of them had at least a Bachelor Degree. Most of them lived and worked in the urban city area (70%).

PROCEDURE

In order to examine the level of awareness between the conventional intervention: brochures, and the use of intervention technology: virtual environment, a between-participants design study with pre-post experimental study was held. The participants were randomly divided into two groups (Group A: n =15 and Group B: n = 15). Both were controlled experiment and this approach had been chosen to avoid the learning effects and the possibility of experimental manipulation having effect in more than one condition.

The participants were welcomed and briefed about the purposes of the experiment before signing the consent form. They were briefed on the MyRedList including how to use the HMD for Group A and the use of the printed brochures for Group B.

Firstly, they had to answer the pre-questionnaire which included demographic questions and questions about forest conservation in Malaysia including threatened plant species. When they were ready, each of the participants in Group A were given a laptop with access to MyRedList. The participants were permitted to explore the virtual environment with no time limit. Each of the participants in group A were also given a HMD that was already attached with a smartphone to view the virtual forest in MyRedList, including the habitat for Meranti Belang and Resak Daun Panjang. While participants in group B were given some brochures explaining about the Threatened Plant Species in Peninsular Malaysia.

After using MyRedList (for group A) and after reading the brochures (for group B), all participants in both of the groups were asked to fill in a post-questionnaire. Data was collected after all the sessions were held with all of the participants.

RESULTS AND DISCUSSION

The 30 participants completed the experiment and fully filled in the pre and post questionnaires. The analysis of the data of the study shows a significant increase in awareness regarding the threatened plant species in Peninsular Malaysia.

The dataset uses the placement test score of the Likert scale (1-5) on the awareness of threatened plant species for both experiments on virtual environment and brochure usage. We want to determine whether virtual environment or brochure usage had higher test scores after usage of both media on average. TABLE 2 shows the difference in mean score for virtual environment usage (group A) and brochure usage (group B).

TABLE 2. Difference mean score for virtual environment usage (group A) and brochure usage (group B)

Respondent	Group A	Group B
1	4.91	3.18
2	4.82	3.27
3	4.64	3.27
4	4.64	2.82
5	4.36	2.91
6	4.91	3.36
7	3.91	3.09
8	4.00	3.09
9	4.73	3.00
10	4.27	3.36
11	4.55	3.45
12	4.27	2.64
13	3.91	2.82
14	4.09	2.55
15	4.45	2.45
Total mean	66.46	45.26
Mean (*M*)	4.43	3.02

Variable post-test on virtual environment (Group A) had a high of 4.91 and a low of 3.91, while variable post-test on brochures (Group B) had a high of 3.27 and a low of 2.45. The mean virtual environment score was higher than the mean brochures score (4.43 versus 3.02).

Referring to Figure 3, there are obvious significant increases with the post-test for virtual environment (group A) compared to the post-test with brochures usage (group B) on the

awareness of threatened plant species in Malaysia. After using the virtual environment application, group A had increased awareness on the matter (*M*=4.4303, *SD*=.08981) compared to using brochures (*M*=3.0182 and *SD*=.08092). From the box plot, the centre of the post-test virtual environment scores is much higher than the centre of post-test brochures scores.

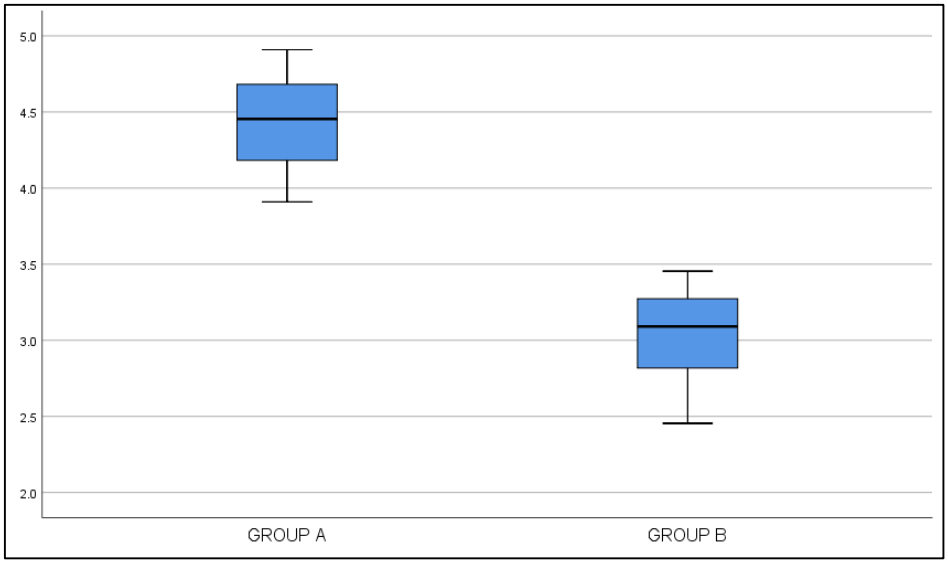

FIGURE 3. Boxplot of pre-test and post-test for both brochure and MyRedList

We used an independent-samples t-test to test if there was significant difference in the average of the two sets. Homogeneity variants test should be carried out before conducting further analysis. The following Table 3 is a homogeneity analysis showing that p> .05 supports that data has the same or homogeneous variants. These results can determine which further tests can be performed.

TABLE 3. Homogeneity variants test

	Levene statistic	***df1***	***df2***	***Sig.***
Mean score	0.297	1	28	0.59

The next analysis is the independent sample t-test. After finding the data is normal and homogeneous, independent sample t-tests can be carried out. This test was selected based on the fact that both groups were not involved with one another and were from different individuals. Table 4 shows the mean score in the brochure post-study study was lower (3.0182) than the post-mortem study report (4.4303).

TABLE 4. Difference mean score between group A and group B

	Respondent	***n***	**Min**
Test results	Group A	15	4.4303
	Group B	15	3.0182

Table 5 describes the evaluation of independent sample t-tests on post-study data for both media, which is the use of virtual environment (group A) and brochures (group B). The hypothesis null for this study is MyRedList cannot increase the awareness of threatened plant species. The questionnaire in this study focused on asking the participants about their

knowledge of threatened plant species and whether the deforestation, infrastructure development and conservation of the threatened plant species could increase the awareness of threatened plant species. As the levene test data p> 0.05, the significant value of this study was taken on the line of variance, assuming there was a significant difference between the use of MyRedList and the brochure, thus rejecting the null hypothesis with p <.05 (p = .000). Mean difference of > 0 indicates the virtual environment had a higher mean score. With results of this analysis, it can be concluded that virtual environments can provide more awareness of threatened plant species than the use of printed brochures.

TABLE 5. Independent sample t-test between group A and group B

	Levene's Test for Equality if Variance		t-test for Equality of Means		
	F	Sig.	df	Sig. (2-tailed)	Mean Difference
Equal variances assumed	0.297	0.590	28	.000	1.41212
Equal variances not assumed			27.702	.000	1.41212

The significant value of the two-tailed test is less than 0.005 ($p < 0.005$), therefore it can be concluded that there is increased awareness of threatened plant species in Malaysia with the usage of virtual forest environment (group A) compared to after the usage of brochures (group B).

The contribution of this study are: (1) this study has created a technology of web virtual environment for threatened plant species that can increase the knowledge and awareness and, (2) the conceptual framework on designing the virtual environment for the threatened plant species.

CONCLUSION

In conclusion, this study has developed a web virtual environment that can increase the knowledge and awareness of threatened plant species. The present study shows that there is a significant difference in the awareness of threatened plant species after using MyRedList, a web based virtual environment application, compared to brochures. The participants were more aware on the threatened species after the usage of MyRedList. The participants can still enjoy the beauty of nature of the habitats of threatened plant species through web based virtual environment technology without disturbing the actual habitat. MyRedList can improve the awareness on the focus subject, therefore, conservation activities of threatened plant species have the potential to be carried out actively, potentially further enhancing the recovery efforts of threatened plant species. When there is increase of awareness, it can also assist in managing the tropical forest resources on a sustainable basis in this country. This research can be further validated by increasing the number of participants in the studies and adding more plant species in the scope of the study for future research.

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