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# EVALUATION OF E-STAR: AN ENHANCED SCIENCE TEXTBOOK USING AUGMENTED REALITY AMONG LOWER SECONDARY SCHOOL STUDENTS

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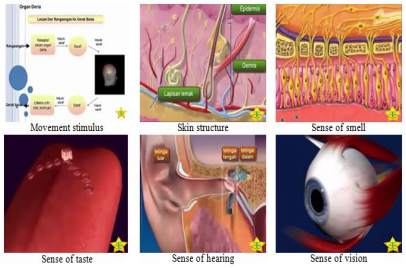
## Graphical abstract




## Abstract

As a developing country, Malaysia needs to produce adequate human resource in science and technology related fields. This is important especially towards making Malaysia a developed nation by 2020. Unfortunately, there is a downward trend in the number of students pursuing the science stream at the secondary education level. Lack of motivation has been identified as one of the cause of this phenomenon. This paper introduces an enhanced science textbook using Augmented Reality (e-STAR) application that facilitates students in science learning. The e-STAR is intended to motivate the students to be more interested in science. This paper also discusses on the evaluation of the e-STAR among a sample of form two secondary school students. Quantitative data was collected using questionnaires for evaluating the following dimensions: motivation, ease of use, engaging, enjoyment and fun. The results indicate that the users agreed on all the dimensions. The findings proved that the e-STAR application can be one of the potential solutions to the above mentioned phenomenon.

*Keywords*: Augmented Reality textbook, Science learning, e-STAR, Evaluation

## Abstrak

Sebagai sebuah negara yang sedang membangun, Malaysia perlu melahirkan sumber manusia yang mencukupi dalam bidang berkaitan sains dan teknologi. Ini penting terutama ke arah menjadikan Malaysia sebuah negara maju menjelang tahun 2020. Malangnya, terdapat satu trend menurun dalam jumlah pelajar yang mengikuti aliran sains di peringkat pendidikan menengah. Kurangnya motivasi telah dikenal pasti sebagai salah satu punca fenomena ini. Kertas ini memperkenalkan aplikasi buku teks sains dipertingkatkan dengan menggunakan realiti luasan (e-STAR) yang memudahkan pelajar dalam pembelajaran sains. E-STAR bertujuan untuk memotivasi pelajar untuk lebih berminat dalam bidang sains. Kertas ini juga membincangkan mengenai penilaian terhadap e-STAR dikalangan sampel pelajar tingkatan dua sekolah menengah. Data kuantitatif telah dikumpulkan dengan menggunakan soal selidik untuk menilai dimensi berikut: motivasi, kemudahgunaan, penglibatan, kenikmatan dan keseronokan. Hasil dapatan menunjukkan bahawa pengguna bersetuju dengan semua dimensi. Penemuan membuktikan bahawa aplikasi e-STAR berpotensi menjadi salah satu penyelesaian untuk fenomena yang dinyatakan di atas.

*Kata kunci*: Buku Teks Realiti Luasan, Pembelajaran Sains, e-STAR, Penilaian

## 1.0 INTRODUCTION

As a developing country, Malaysia needs more human resources and expertise in various fields related to science and technology. Moreover, the government has decided that Malaysia should be enhanced to become a fully developed and industrialized country by the year 2020 as outlined in the 2020 Vision. As such, mastery in various fields of science and technology will enable Malaysia to build the strength to be competitive with other developed countries [1]. Science learning should be given more priority since it plays a major role in assisting a country to achieve the developed country status [2]. Science learning especially in the secondary school is considered very prominent because it provides students with the knowledge and skills that enable them to solve problems and make decisions.

Unfortunately, over a few decades, Malaysia is facing a downward trend in science-related professions and careers among the younger generations [3]. The government has established a 60:40 (60% Science and 40% arts) education policy in order to balance the number of students studying in science and technology over the arts. In the mid 1980's, the ratio of science to arts students declined to 31:69; in the 1990's, the ratio further declined to 22:78 and it remained at 20:80 until 2012 [4]. Moreover, only 29% of the students were pursuing the science stream in the secondary schools [5]. Trends in the International Mathematics and Science Study (TIMSS 2011)[6] reported that the interest among form two students in science learning has been declining by approximately 17% from the year 2003 to 2011[4].

There are many external factors affecting the students' attitudes towards science and they become less positive from the age of 11 to 16 [7]. Lack of interest is considered as the main cause of the declining performance towards science in the classroom [7]. Nowadays, students of the generation Z are technology savvy, gadget freaks and living in a world that has always had the internet [8; 9]. They are connected to their peers globally through the social media and they have the access to knowledge at their fingertips through the internet. Most of them are used to all the gadgets such as laptops, Smartphone and tablets since they are kids. Thus, when they are using textbooks with only text and images as contents, they have very little interest and would easily get bored with the books [9; 10]. Besides that, the way the teaching materials are presented in the class might probably be one of the reasons why students found science is difficult [11].

The circumstances mentioned above lead students to lack in motivation. Motivation is an act which encourages someone to do some action [12]. In a learning environment, motivation deals with the problem of setting up conditions so that the learners will perform the best of their abilities in academic [12]. In the learning process, active learning requires the learners to learn new information and find ways to put it to use [13]. Moreover, the generation Z has been immersed in a variety of emerging technologies since birth thus they have different learning preferences compared to the previous generations [14]. The current teaching and learning approaches need to be reformed to accommodate and optimize their learning experience.

In the past, many researchers have identified the vast potential and numerous benefits of Augmented Reality technology in teaching and learning [15 - 19]. AR allows computer generated virtual imagery to exactly overlay physical objects in real time [20]. AR generates a coalition of real world environment scene and virtual world environment scene produced by the computer that augments the scenes with additional information materials such as text, images, audio, video and graphics based on the real world perception [21]. Through AR, the computer can generate an environment which is similar to the real world environment. AR has proved its ability by partaking in and motivates students in the learning process for a long time [22; 23]. AR offers unique affordances, combining physical and virtual worlds with continuous and implicit user control of the point of view and interactivity [22]. AR has been proven to have good potential in education, however; it has not been introduced into the Malaysian education settings especially for the purpose of science learning in the secondary schools.

In the following sections, we provide a brief introduction to the e-STAR application, describe the evaluation of the application, elaborate on the results of the evaluation and finally conclude the paper.

## 2.0 E-STAR: THE ENHANCED SCIENCE TEXTBOOK USING AUGMENTED REALITY

In order to introduce a new form of learning for students, we decided to develop the e-STAR application, an enhanced science textbook using AR. E-STAR is based on the existing science textbook for Form Two which is provided by the Ministry of Education of Malaysia (MOE). However, this textbook consists of texts and images only which easily bores the students especially the generation Z. As such, we decided to use the existing textbook in order to cut the cost and provide the additional virtual contents through the use of the AR technology. The development of the e-STAR application followed the design guidelines as outlined in the e-STAR Conceptual Model [24]. Besides that, we also incorporated suitable features in the AR book based on our previous study [25].

The contents of the e-STAR COVER two chapters of the form two science textbook namely; "The World through Our Senses" and "Nutrition". The content of

the application plays a vital role in this study and it must be comprehensive, fulfils the requirements set by the MOE and suitable for form two science learning. The content must be accurate and simple to learn and understand for that age group of students. Figure 1 shows some screenshots of the contents that have been applied in the e-STAR application.

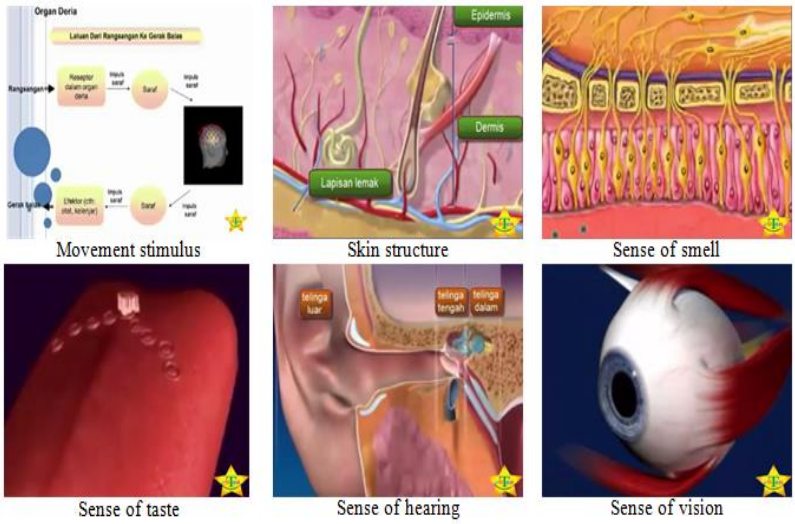



**Figure 1** Some screenshots of the e-STAR contents

## 3.0 E-STAR EVALUATION

The e-STAR evaluation comprises of heuristic and user evaluations.

### 3.1 Heuristic Evaluation

The heuristic evaluation is categorized into two namely; i) content evaluation and ii) functionality and interface evaluation. For the content evaluation, the experts involved were two teachers who are teaching the Form Two science subjects in the secondary schools. They are required to validate the content of the e-STAR application to ensure that it follows the Integrated Secondary School Curriculum and also suitable for Form Two students. Meanwhile, for the functionality and interface evaluation, the experts involved were two lecturers who have experience in the teaching and development of multimedia applications. They are required to use the e-STAR and identify any problems related to the functionality and interface of the application. For the functionality and interface evaluation, ten criteria as suggested by [26] were used and are shown below.

i. Visibility of system status.
ii. Match between system and the real world.
iii. User control and freedom.
iv. Consistency and standards.
v. Error prevention.
vi. Recognition rather than recall.
vii. Flexibility and efficiency of use.
viii. Aesthetic and minimalist design.
ix. Help users recognize, diagnose, and recover from errors.
x. Help and documentation

### 3.2 User Evaluation

The aim of this evaluation is to determine the users' perception towards the use of the e-STAR application which combines the existing science textbook and the AR technology.

*Respondents.* The user evaluation was conducted among a sample of 70 Form Two students utilizing the purposive sampling technique. The sample size satisfies the requirement stated by [27] whereby the minimum number of samples must be at least 30. The user evaluation has been conducted in a secondary school in Kuala Kangsar, Perak.

*Instrument.* The instrument for the user evaluation consists of a set of questionnaires which includes dimensions that were taken from previously validated instruments and modified based on the AR learning environment context. The dimensions are Ease of use, Engaging, Enjoyment, Fun and Motivation. The questionnaires adapted most of the items from the Instructional Material Motivational Survey (IMMS) which have been modified by [28] and Science Motivation Questionnaire II (SMQII) [29]. Among these dimensions, the items for Fun were cited from [29 - 31]. The evaluation questionnaires consist of two sections namely; user's demographic data and user's perception of the application. A 5-point Likert scale

anchored by "Strongly Disagree" (1) and Strongly Agree (5) was used.

*Method of Evaluation.* Prior to the user evaluation, a brief explanation regarding the usage and the user interface of the e-STAR application was given to the respondents. They were given ample time to go through the e-STAR application and use it for the purpose of science learning on their own. Then they were given a set of questionnaires for the user evaluation.

## 4.0 RESULTS

### 4.1 Heuristic Evaluation

From the ten stated criteria, the experts have identified several minor problems in some of the criteria. Table 1 shows the problems that have been identified by the experts and the suggested solutions to the problems. Feedbacks and recommendations from the experts were documented and earlier version of the e-STAR application was modified according to their suggestions.

**Table 1** Problems and Solutions for Heuristic Evaluation of the e-STAR application

| Heuristic | Expert Comments | |
|---|---|---|
| | **Problem** | **Solution** |
| 1. Visibility of system status | • Few AR markers are slow to be detected and response. | • Recheck and standardize the AR markers' size.<br>• Avoid same type of images. |
| 2. Match between system and the real world | • Standardize the marker illustration either with real images or cartoon images. | • Changed the AR Markers to real images in order to attract learners. |
| 3. User control and freedom | - | - |
| 4. Consistency and standards | • Video regarding sense of taste has a spelling error.<br>Suggestion<br>• Variety in presenting the content such as video, audio, text, animation and 3D models is good and enough to motivate students. | • The word for the video supposed to be tongue instead of the ear. It was corrected. |
| 5. Error prevention | • Technical glitches exist because it might stop learners from continuing with the application.<br>• Few background sounds are looped. | • Avoid technical glitches. It might stop learners from continuing with the application.<br>• Avoid the looping of certain sound in background. |
| 6. Recognition rather than recall | - | - |
| 7. Flexibility and efficiency of use | Suggestion<br>• Presentation is good, but provide with a skip button.<br>• So, an experienced user can skip the introduction phase and straight to the learning phase. | - |
| 8. Aesthetic and minimalist design | Suggestion<br>• Presented content for each chapter is comprehensive and suitable for students | - |
| 9. Recognize, diagnose, and recover from errors | - | - |
| 10. Help and documentation | Suggestion<br>• Clearly state where to stick the marker in the science textbook.<br>• Provide a step-by-step guide on how to use the AR application and provide introduction about e-STAR. | - |

### 4.2 User Evaluation

*Demographic characteristics.* 32 respondents are male and 38 respondents are female. Since all the respondents were Form Two students, they were 14 years old when they participated in the evaluation. The respondents comprised of 42 (60.0%) Malays, 17 (24.3%) Chinese, 9 (12.9%) Indians, and 2 (2.9%) were

from other races. The respondents were from four different classes. All the respondents have laptops at home and 40 (57.1%) of the respondents have internet facilities at home. 22 (31.4 %) of the respondents have some knowledge about AR.

*Reliability analysis.* The purpose of the reliability analysis is to identify the internal consistency of the questionnaires. The Cronbach Alpha values were calculated using the SPSS version 22 as shown in Table 2. Since all the Cronbach alpha values are greater than 0.7, thus all the dimensions and items are interrelated and reliable [32].

*Descriptive statistics*. User evaluation is prominent in obtaining users' perceptions towards the use of the e-STAR application. The descriptive statistics analysis was conducted to determine the mean score and the standard deviation of each item using the SPSS version 22 as shown in Table 3.

**Table 2** Cronbach Alpha Values for All Dimensions

| Dimension | Number Of Items | Cronbach Alpha *a* |
|---|---|---|
| Motivation | 6 | 0.865 |
| Ease of use | 6 | 0.780 |
| Engaging | 4 | 0.836 |
| Enjoyment | 4 | 0.802 |
| Fun | 4 | 0.774 |

**Table 3** Descriptive Statistics for All Dimensions and Items

| Item | Mean | Std. Deviation |
|---|---|---|
| **Ease of use** | **4.10** | |
| 1. e-STAR is easy to use. | 4.03 | 0.659 |
| 2. e-STAR is suitable to apply in Science subject. | 4.23 | 0.802 |
| 3. e-STAR is suitable to use as a revision tool in the Science subject. | 4.01 | 0.732 |
| 4. Augmented Reality is suitable for personal use. | 4.09 | 0.864 |
| 5. The step to use the e-STAR is easy to remember. | 4.11 | 0.790 |
| 6. e-STAR has made the revision process easy | 4.14 | 0.767 |
| **Engaging** | **4.03** | |
| 1. e-STAR attracts my interest in studying science for a long time. | 4.03 | 0.851 |
| 2. e-STAR makes me repeatedly revise science subject. | 4.03 | 0.916 |
| 3. e-STAR makes me involve in science learning for a long time. | 4.00 | 0.742 |
| 4. e-STAR increases my involvement in science learning. | 4.07 | 0.822 |
| **Enjoyment** | **4.11** | |
| 1. I really like and enjoy the e-STAR application for science learning. | 4.00 | 0.681 |
| 2. e-STAR makes me deeply enjoyed the uniqueness of science. | 4.14 | 0.785 |
| 3. I enjoy learning science by using the e-STAR. | 4.09 | 0.676 |
| 4. e-STAR cultivates the interest in learning science. | 4.23 | 0.765 |
| **Fun** | **4.25** | |
| 1. e-STAR is fun to use in science learning. | 4.26 | 0.674 |
| 2. Content of the e-STAR adds more fun in science learning. | 4.29 | 0.705 |
| 3. I enjoyed using the e-STAR as a revision tool in science. | 4.23 | 0.663 |
| 4. e-STAR learning is fun compared with the conventional textbook with normal text. | 4.24 | 0.731 |
| **Motivation** | **4.15** | |
| 1. e-STAR is really easy to use. | 4.19 | 0.708 |
| 2. e-STAR increases my involvement in science learning. | 4.13 | 0.779 |
| 3. I enjoyed the process of learning science for a long time. | 4.01 | 0.712 |
| 4. Learning science is more fun with the use of e-STAR. | 4.17 | 0.780 |
| 5. e-STAR increases my motivation to achieve high in science. | 4.20 | 0.651 |
| 6. e-STAR encourages me to pursue higher education and careers related to science in the future. | 4.21 | 0.657 |

## 5.0 DISCUSSION AND CONCLUSION

The continuous decline in the number of students pursuing science stream in the secondary schools is worrisome. There are many external factors affecting the students' attitudes towards science learning. Students' lack of interest in science is one the factor which can lead to students' lack in motivation. Students of the generation Z who live in the digital world require a paradigm shift in the science learning methods through the introduction of new innovations and technologies that can attract their attention and increase their interest. This paper has looked into the possibility of utilising the AR technology by enhancing the existing science textbook through the development of the e-STAR application.

A set of questionnaires was used to record the perceptions of the students towards the use of the e-STAR application. The results showed that the mean scores are 4.10 for Ease of use, 4.03 for Engaging, 4.11 for Enjoyment, 4.25 for Fun and 4.15 for Motivation. Fun has the highest mean score of 4.25 while Engaging has the lowest with a mean score of 4.03. Since all the dimensions have mean scores of greater than 4.0, these indicate that the users agreed on all the dimensions. Besides that, the experts also found that the e-STAR application complies with all the required standards both in terms of the contents as well as the functionality and interface.

Overall, this study highlights the importance of innovative and creative method for science learning through the utilization of the e-STAR application. Thus, our effort in developing the application coincides with the need to introduce a new science learning method for the students of the generation Z. Our effort in developing the e-STAR application coincides with the need to increase the number of secondary school students pursuing the science stream so that the government's 60:40 education policy could be a reality. It is hoped that the findings of this study will encourage the Ministry of Education to consider the e-STAR application as a supplement to the conventional science learning in schools.

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