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Design and Construction of the Learner-centered E-learning System for Facilitating Dermoscopy Image Analysis and Diagnosis in Medical Education

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Abstract: Dermoscopy is a noninvasive imaging technology that allows visualization of deeper skin structures by reducing surface reflectance, also supports more accurate diagnosis in early stage in melanoma. Compared to clinical training, learning diagnosis and related knowledge via e-learning system could be more convenient and efficient because learning materials can be collected organized based on pedagogical rationale, and users can learn personally anytime and anywhere. Thus, in this study we aim to focus on designing and implementing an e-learning system that provides well-designed images, interactive and intuitive learning environment for medical students to actively learn melanoma dermatopathology more effectively. The development of the system focuses on learning content design and instructional design. In the learning contents, the primary image resources intend to be the numerous learning materials in two steps: to reduce noise in images, and to add noise in images. After new resources are synthesized, its type can be confirmed by deep learning system. The final AUC of classifying diseases is over 0.85 with our system. In order to get the system improved, we conducted the formative evaluation to the 10 target learners. Overall, the participants are positive to the self-directed e-learning system. Moreover, some useful comments were provided for enhancing the system. The four instructional design features applied to this system include: (1) intuitive correspondence between lesion and diagnosis; (2) segmented components with structural organization; (3) terminology with link and clear tracing document; and (4) personalized system. According to the above rational and strategies, this e-learning system is expected to be a better self-directed learning platform that can afford the target users to learn flexibly, with massive resources and intuitive instructions and learn the technique of accurate diagnosis more effectively; the formative evaluation also showed that learners may have higher learning efficiency and motivation with this self-directed e-learning system. Currently the system is still undergoing, final result will be presented in the future.

Keywords: Medical education, Self-directed learning, E-learning system, Dermoscopy image

1. Introduction

In medical education field, faculty, administrators, and learners find that multimedia e-learning enhances both teaching and learning. Chumley-Jones et al. (2002) cited several studies assessed learners' preference for web-based learning. Most learners in medical, dentist and nursing background preferred web-based learning to continuing medical education conferences, lectures, video, audiotapes, journals, or textbooks. Compare to other learning methods, the accessibility, navigation, and attractiveness predict learners' satisfaction in web-based learning (Bouhnik & Marcus, 2006).

Early diagnosis of melanoma is of critical importance for patient prognosis. With pigmented lesions occurring on the surface of the skin, melanoma is amenable to early detection by expert visual inspection. Although skin lesions are visible to the naked eyes, early-stage melanomas may be difficult to distinguish from benign skin lesions with similar appearances. This has led to many missed melanomas despite an epidemic of skin biopsies.

Dermoscopy is a vivo imaging technique that can clearly identify the criteria of pigment network, which may not see by naked-eye. ISIC, the international skin imaging collaboration, has released over 10000 lesion images captured by dermoscopy to the public, provided people to utilize for noncommercial purpose. Based on these images, it is more likely to observe the early stage of

melanomas by visual inspection. Its use increases diagnostic accuracy between 5% and 30% over clinical visual inspection, depending on the type of skin lesion and experience of the physician.

To assist the training for medical students in visual diagnosis, author aim to design and develop an e-learning system for medical students. The goal for this system includes: to help students observe and learn the method to utilize dermoscopy images in diagnosis, learning contents and examinations will take place in this learning system.

2. Literature Review

Mayer et al. (2014) had listed three important instructional goals which enhance the effectiveness on learning: to reduce extraneous overload, to manage essential processing, and to foster generative processing during learning. Knowles (1975) had listed three immediate reasons why self-directed learning is important: (1) active learners learn more and better than passive learners, and active learners have more purposefully and with greater motivation in learning; (2) self-directed learning is more in tune with our natural process in psychological development, similar to the progress we became independent and responsible to ourselves; and (3) new developments in education put heavy responsibility on the learners. Rapid change becomes the only stable characteristic in this new world, thus self-directed learning is important when knowledge updates in short period of time.

Continuing technological advances are inevitably impacting the study and practice in dermatopathology. Shahriari et al. (2017) had reviewed the recent flow of growth and change in dermatopathology learning. In the online learning section, the authors mentioned that most of the online information for dermatopathology is limit to biopsy resources, less of them focus on dermoscopy images. For e-learning platforms that provide dermoscopy image analysis training, the great majority of these platforms are type of distance learning videos, ppts or image database, which are lack of interactive and autonomous learning methods, and way to practices. However, with these online resources, users are no longer limited to communicating only within their own institutions, but the establishment of online communities allow the public to reach dermatopathology knowledge easily.

3. Methods

3.1 Learning Content Design

The main purpose of this e-learning platform is for learners to gain clinical experiences with dermoscopy image online. Because the design of contents focuses on the image of skin diseases, large database of dermoscopy images is important for this system. Besides collecting dermoscopy images from open databases, simulated images based on real dermoscopy images can enhance the amount of learning resources. There are three steps to auto stimulate numerous lesion images which are highly realistic:

Hair is the most significant noise in dermoscopy images, the difference in color and shape can become the characteristic for detecting. Generally, hair is relatively darker than skin color, which can be separated by adaptive thresholding. Next, hair usually presents in slender shape, which can be picked out by selecting the geometric shape. It is important not to pick out scars from image, scars have similar color but different geometric characteristic to hair. After selecting all noise in image, the noise areas are filled in by Telea's FMM inpaint method (Telea, 2004).

With the same method of noise detecting in the above section, noises can be drawn and added in noise-reduced dermoscopy images.

After new images are synthesized, the type of disease can be confirmed by deep learning system. In 2018, we have done a disease classifier with the mean AUC (area under curve) of lesion diagnosis reached 0.85; in the ISIC challenge 2018, the best classifier has a mean AUC of lesion diagnosis reached 0.983.

3.2 Instructional Design

3.2.1 Intuitive Correspondence Between Lesion and Diagnosis

For learners who are learning to diagnosis diseases via dermoscopy images, the discernment in trifling pigment network makes it hard to get started. To provide clear classification and correct location of pigments and other disease characteristics, corresponding information is placed in the side window which shows when cursor reached the lesion attribute.

3.2.2 Segmented Components with Structural Organization

Focusing on learning dermoscopy imaging analysis, the construction and structure of the large scale of learning contents become an important issue. With appropriate segmented components and structural organization, it is possible to reduce extraneous overload and essential overload in learning process.

3.2.3 Terminology with Link and Clear Tracing Document

The relation and explanation of professional terminologies are complicated and confused. We added hyperlink to specific terms to emphasize the relationship between every links. Clear flow in connections reduces essential overflow in learning process and gives learners logical organization within whole content.

3.2.4 Personalized System

Highlighting unfamiliar contents and bookmarking important parts help learners to enhance the efficiency of learning, without reviewing known knowledge repeatedly. Based on the personalized information, the examination is designed to choose questions those learners are unfamiliar with.

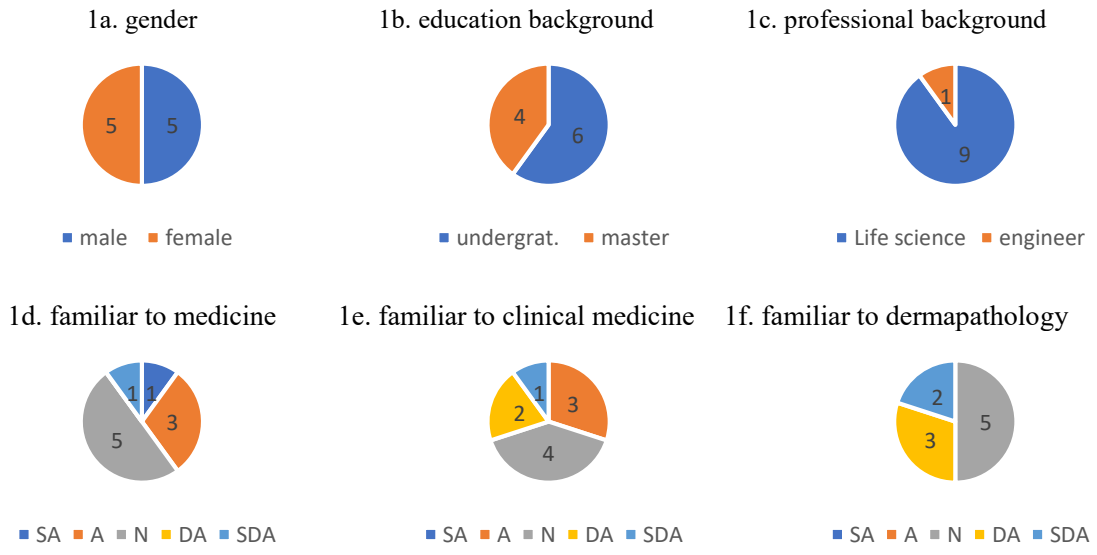
4. Formative Evaluation and Result

The system is still in prototype stage, the formative evaluation was conducted to collect responses for the system improvement. In the evaluation questionnaire, questions include five-point Linkert scale and open-ended questions from 5-point ‘strongly agree’ (SA), ‘agree’ (A), ‘nether agree or disagree’ (N), ‘disagree’ (DA), to ‘strongly disagree’ (SDA) with 1-point. In the formative evaluation, we intended to collect the target users’ responses to the structural design, function design, visual design and others in text. Ten voluntaries participated in this evaluation from National Tsing Hua University, Taiwan.

Based on the instructional design issues in the method, there are some representative views of this learner-centered e-learning system listed as below.

Table 1

The consistence of evaluators (n = 10)



4.1 Intuitive Correspondence Between Lesion and Diagnosis

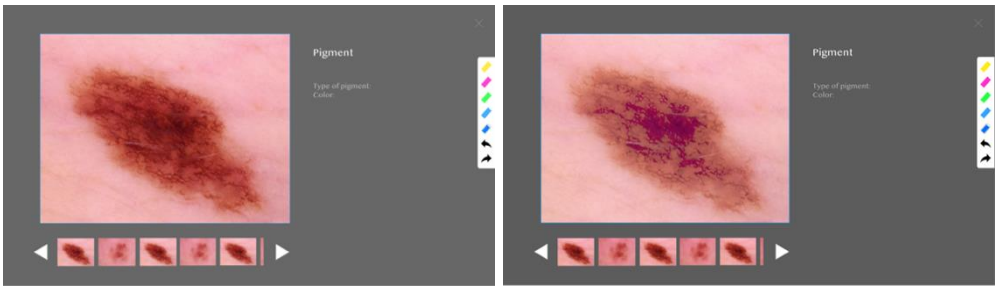


Figure 1. System screenshot – image diagnosis learning sample page

Figure 1 presents the function of intuitive correspondence between lesion and diagnosis. This page is designed with: clicking the lesion or characteristic area in the image, the similar area will be emphasized with different color, which provided learners to distinguish the different specialized area intuitively.

Table 2

Intuitive correspondence between lesion and diagnosis (n = 10)

	SA	A	N	DA	SDA	Avg	SD.
Learners could gain wanted information of images in this page.	30%	40%	30%	0%	0%	4.0	0.8
The function of changing color of clicked specialized characteristic is useful.	50%	40%	10%	0%	0%	4.4	0.7
The function of changing color of clicked specialized characteristic is better comparing to traditional teaching method, pointing out characteristic by arrow-pointing and circling.	70%	10%	20%	0%	0%	4.5	0.8
The design of this image diagnosis webpage is an ideal self-directed e-learning system.	30%	50%	20%	0%	0%	4.1	0.7

According to the result of formative evaluation, all of the questions related to intuitive correspondence between lesion and diagnosis got the average score over 4 (out of 5). Especially comparing to traditional teaching method, this intuitive presentation provides better learning efficiency with the average score 4.5-out-of-5. In the open question, one evaluator had suggested that adding the highlighting function to image characteristic. The results supported that the design is intuitive and can reduce extraneous overload in learning process.

4.2 Segmented Components with Structural Organization

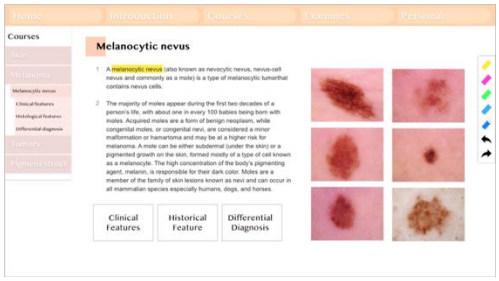


Figure 2. System screenshot – course page sample.

Figure 2 is a screenshot of the course page that related to segmented components with structural organization. In this sample, the index on the left side is listed in stair structure with different color style; in the center of this page, contexts are separated with number at the start of the paragraph; related images are placed on the right of this page, learners can link to the page of image diagnosis learning by

clicking images; on the side of the page, highlighter bar provides learners to emphasize important message delivered in the text content.

Table 3
Intuitive correspondence between lesion and diagnosis (n = 10)

	SA	A	N	DA	SDA	Avg	SD.
The design of the page is simplified.	50%	40%	10%	0%	0%	4.4	0.7
The structure of this website is easy to understand.	20%	60%	20%	0%	0%	4.0	0.7
The index could guide them to needed pages rapidly.	10%	70%	20%	0%	0%	3.9	0.6
The level relationship of the sidebar is clear.	50%	30%	20%	0%	0%	4.3	0.8
The display of text content and image content is consistent.	10%	80%	10%	0%	0%	4.0	0.5

According to formative evaluation, most of the questions related to segmented components with structural organization got the average score of 4. The question with relatively lower score is about process of gaining contents from the website, while the questions about structure got higher scores. It is surmised that the indicator written in text is not that clear comparing to visual structure; improvement in text designing should be considered in the system. In the opening question, one evaluator suggested that the design of sidebar in course section should remain the options even not selecting them; the original design of the sidebar is remaining the directed parent items of current page and the items in first level.

4.3 Terminology with Link and Clear Tracing Document

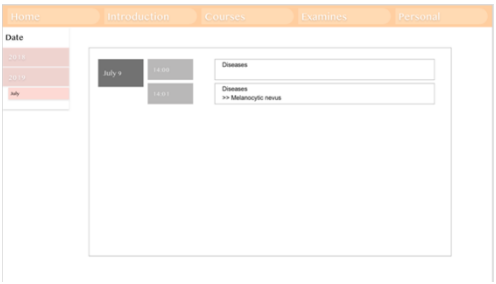


Figure 3. System screenshot– linking list sample page.

In figure 4, it showed the history of their personal browse record. Classified by time, this page recorded the page and section learners had clicked before; linking to related course page is also available.

Table 4
Terminology with link and clear document

	SA	A	N	DA	SDA	Avg	SD.
The design of linking list could assist learners to sort out their thread of thought.	30%	40%	30%	0%	0%	4.0	0.8
The design of linking list can enhance the efficiency of learning.	30%	30%	40%	0%	0%	3.9	0.9

According to the result of formative evaluation, the design in terminology with link and clear document is slightly useful. In the opening question, evaluators had suggested that related website link can also add in this system. Concluding both parts of the evaluation, this function supports learning process, although it might not be one of the most important issue in self-directed e-learning system.

4.4 Personalized System

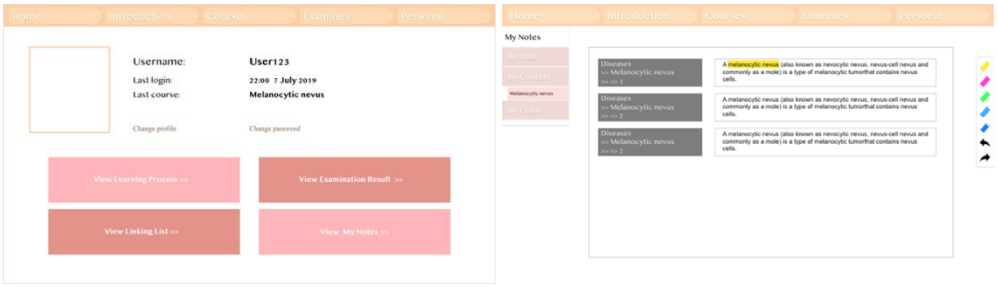


Figure 4. System screenshot – Personal page & My notes.

The design of personalized system covers several topics: in the course pages (figure 1, 2), the right-side sidebar listed highlighting tools with 4 colors, eraser, backward and forward function button. These tools were desgined for marking text contents, and these emphasized paragraph will also occur in 'my notes' page arranged by course, highlighter's color, or date. In the 'my notes' page (figure 4), the marked contents were placed in paragraph, and by clicking the gray blocks in page, learners can link to the content in course page.

Table 5
Personalized System

	SA	A	N	DA	SDA	Avg	SD.
It is useful to highlight keynotes in text context.	50%	30%	20%	0%	0%	4.3	0.8
The design of multi-color highlighters is efficient for learning.	40%	40%	20%	0%	0%	4.2	0.8
Classification in 'my notes' is useful for searching needed notes.	20%	60%	20%	0%	0%	4.0	0.7
The presentation method of notes makes evaluators clear to get notes.	30%	50%	20%	0%	0%	4.1	0.7
The link between 'my notes' and the related course makes clear thread of thoughts.	40%	40%	20%	0%	0%	4.2	0.8
The design of personalized page supports deeper learning in self-directed e-learning system.	40%	40%	20%	0%	0%	4.2	0.8

The results of the personalized system are all positive with a scores above 4.0. In the open question, evaluators had suggested that it will be useful if there is function for texting learners' own note or adding a discussing forum for learners to communicate with.

Some evaluators had suggested that the theme color of the website is corresponded to the topic (skin and skin diseases), but the light background and white texts let their eyes feel tired after long time of usage; some contents are too small to look at, adding function for zoom in/zoom out may enhance the efficiency of learning. Other opinions such as gray blocks looked unexpected, or excepting video contents are mentioned.

5. Conclusion and Future Work

From the feedback of the formative evaluation, it could be understood that participants were positive to this system, some useful and constructive opinions or suggestions were also presented. The instructional design, concepts of visualization, interaction, autonomy and assessment presented in this system support medical student to learn dermoscopy image analysis. The suggestions in the formative evaluation will be integrated into our design for improving the self-directed system. Furthermore, we hope to conduct the environment after the system is ready for use in the authentic setting in the future.

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