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AI-Driven mobile application for enhancing efficiency and preserving herbal knowledge

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Abstract

Traditional Thai medicine and local herbal knowledge are important local wisdom heritages, yet there are still limitations in access and methods of knowledge transfer. Therefore, this research aims to develop a mobile application for herbal information search by photographs. This application collects 30 ancient herbal medicine recipes from 4 provinces in the lower northeastern region, namely Surin, Buriram, Chaiyaphum, and Nakhon Ratchasima. The application is developed by using Extreme Programming approach which applies Convolutional neural network (CNN: DenseNet201) model on TensorFlow. The model is trained with 4,211 herbal images covering 30 species, with an accuracy of 92%. The system includes a function that allows users to add new herbal data, which must be validated by 5 users. In addition, there is a learning media on herbal medicine recipes in multimedia format developed according to the ADDIE Model process. The test results from a sample group of 100 people who passed the purposive sampling criteria, who must have had experience using herbal medicine at least 5 times and have basic knowledge of information technology. The evaluation results found that there was the very highest level of satisfaction in all 3 areas: usability and accessibility ($\bar{x}$=4.25, SD=0.66), system efficiency ($\bar{x}$=4.32, SD=0.71), and content quality ($\bar{x}$=4.36, SD=0.71). The results of relationship analysis between basic factors and satisfaction levels revealed that the service area was the only factor that had a statistically significant effect on overall satisfaction ($p < 0.05$). The results of the research demonstrated that the application of artificial intelligence in combination with multimedia learning media in the application was possible to increase the perception of herbal information. This study demonstrates creative science by integrating traditional herbal knowledge with modern mobile application technology, resulting in a practical and culturally relevant tool developed in the Thai language.

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1. Introduction

Local wisdom in Thai traditional medicine and indigenous herbs represent a body of local wisdom that has been accumulated and transmitted across generations. This knowledge system plays a vital role in disease treatment, health promotion, and self-care practices within community life—particularly in rural areas where access to modern healthcare services remains limited [1–3]. Therefore, herbs are an important alternative for public health care and reflect the self-reliance in health of Thai society. In addition to their medical value, herbal plants as well have a cultural dimension which serves as a role as both a treatment tool and a medium for belief systems, values, and local wisdom, which are related to ethnic diversity, the environment, and the way of life of communities in each region [4, 5]. This knowledge is not only crucial at the local level but also the foundation for holistic health system development. Moreover, the knowledge is a cultural capital worth to be preserved and promoted at the national and international levels.

Although herbal wisdom possesses academic and cultural value, the methods of transmitting this knowledge are still limited to documents, textbooks, or word-of-mouth transmission within the community [3, 6]. Despite it reflects the intellectual roots well, it does not correspond to the learning style of people in the digital age who focus on accessing information quickly, easily understanding, interacting, and self-learning. In addition, the classification of herbal plants in practice still requires specialists, especially the beginner who still lack of ways to access and interactive learning media [7, 8]. Although some research has begun to use Artificial Intelligence (AI) technology to assist in classifying or searching for herbs [9, 10]. However, there is still a lack of mechanisms that allow users to participate in adding information, expressing opinions, or jointly checking the accuracy of content before storing it in a systematic database. This process, known as "collaborative learning", involves multiple individuals engaging in the pursuit of knowledge together. It represents a critical gap which deserves a development in order to facilitate a shift from passive toward active forms of knowledge preservation, participatory learning and knowledge management.

From the aforementioned limitations, there are 3 objectives of this research as follows: 1) to develop educational media on the use of herbal medicine recipes; 2) to develop a mobile application that is able to analyze the identification of herbal plants types from images; and 3) to evaluate the satisfaction of application usage. The developed system applies a convolutional neural network (CNN: DenseNet201) model developed on the TensorFlow platform, which is an extension of previous research [11]. In the development process, the model utilized 4,211 images of 30 species of medicinal plants. The developed application integrates multimedia content for learning about medicinal plants, including videos and infographics. It also allows users to participate in adding and checking information before saving it into the database via a joint verification mechanism of 5 users. This study has collected herbal formula data from 4 prototype provinces as follows: Surin, Buriram, Chaiyaphum and Nakhon Ratchasima, which are in the "Nakhon Chai Burin" group. This group possesses similar herbal cultural roots and diverse local wisdom. Therefore, it is suitable for developing and testing a prototype of a spatial knowledge management system [12]. The developed system aims to be a prototype for future expansion and adaptation to other areas with similar contexts. It is considered an integration of Artificial Intelligence technology with local wisdom to promote the transfer of herbal knowledge.

2. Materials and Methods

Population and sample

The population in this study was people who had used Thai traditional medicine services or herbal medicine usage in the service areas of the Public Health Office in 4 provinces. It was divided into Muang district of 3 Provinces as follows: Surin, Buriram and Chaiyaphum and Sung Noen district, Nakhon Ratchasima Province, which are in the "Nakhon Chai Burin" group with similar cultural contexts and herbal medicine usage. The sample group was selected by purposive sampling from those who had received herbal services at least 5 times according to data from the record system of local public health service institutions and had basic knowledge of information technology, such as using smartphones or basic applications, which was verified with a questionnaire before participating in the research. A sample of 100 participants who passed the above criteria was therefore considered as suitable representatives for the effectiveness and satisfaction evaluation of the prototype application in the context of target users in the local community.

Instruments and quality assessment

Design and development of instructional media

This research uses the ADDIE Model as a framework, consisting of 5 steps as follows:

Step 1 Analysis: The target group of this research was the general public who had positive attitudes towards the use of traditional herbs and had basic knowledge of digital technology. Data from the preliminary survey and interviews with public health officials across four provinces indicate that the majority of learners acquired their herbal knowledge through experiential learning or community-based transmission, rather than through formal education systems. The major problem in learning was the lack of easily accessible and interesting learning media, as most herbal information was in the form of textbooks written by traditional healers and delivered in a lecture format. Therefore, the goal of this learning design focused on promoting knowledge via interactive media.

Step 2 Design – The content given included the usage of 30 herbal formulas for treating illnesses, and learners may access it via video infographics and picture-based internet teaching resources. In order to obtain material and execute learning strategies through self-study [13], learners must utilize a mobile application. Agency employees evaluated a sample group using an assessment form as part of the knowledge evaluation process.

Step 3 Development: The media development consisted of lesson content about ancient Thai herbs, including types, properties, scientific names and usage, along with a video demonstrating how to prepare herbal recipes. Furthermore, the media quality and questionnaires were verified by 3 experts as follows: a lecturer from the Industrial Education Program and 2 officers from the public health agency responsible for Thai traditional medicine, to assess the appropriateness and consistency of content with the research objectives. The content was piloted with a small sample group closely representative of the target population to identify potential errors and inform revision prior to actual implementation.

Step 4 Implementation – In the study, the developed media was employed with the sample group. Staff trained and extensively instructed in media usage in the first phase. Learning the content thereafter took a month. When issues or queries arose throughout the learning process, the learner support method utilized online platforms to facilitate communication between learners and staff.

Step 5 Evaluation – In order to get the most accurate results, the staff interacted one-on-one with the sample group using the media usage assessment form after they had thoroughly learned about the content. A 5-level Likert Scale satisfaction rating represented the assessment's outcome [14, 15].

Deep learning model development

This study was conducted as an extension of the model previously developed and presented in the research by Kunlerd *et al.* [11], The overall process of model development was as follows: DenseNet201 was employed as the primary convolutional architecture for herbal plant image classification. The model was trained using a dataset comprising 4,211 images across 30 herbal species, split into training and test sets in a 70:30 ratio. Early stopping was applied to prevent overfitting, with hyperparameter adjustments guided by the loss observed on the validation set. Evaluation on the test set showed that DenseNet201 achieved a classification accuracy of 92%. This model was subsequently deployed as the core engine in the backend of the application.

Mobile application development

Extreme Programming was used in the development process, which was conducted in accordance with the Agile Software Development Process [16]. The following are the specifics of the procedure:

Step 1 Planning of the application development process: The research was conducted by collecting primary data by conducting field surveys and interviewing relevant persons in local public health agencies, including applying questionnaires and studying data from documents related to herbal operations in the target area to examine the existing nature of activities. Afterwards, the relevant staff were invited to participate in the system requirements by implementing the User Story tool [17] to identify the functions which the system required to support. Once all the information was collected, the research team prepared a summary of the system scope and organized a forum with the original information providers to review, verify the accuracy, and confirm the mutual understanding among both the development team and the original agency before entering the system design phase.

Step 2 Design: The system was designed to consist of 3 main parts as follows: Part 1: System Architecture Diagram which was divided into 3 layers: (1) Presentation Layer, developed as a mobile application to be applied as a channel for interacting with users; (2) Logic Layer, responsible for processing the images of herbal plants; and (3) Data Layer, used for storing and retrieving data in the system, as shown in Fig 1; Part 2: a Use Case Diagram was implemented to demonstrate the roles and permission of users in the system which was divided into general users and administrators, as shown in Fig 2; and Part 3: ER Diagram Design was utilized to design a relational database to define the data storage structure consisting of 8 tables: details, herbs, items, logs, stores, users, admin, revoked tokens as shown in Fig 3.

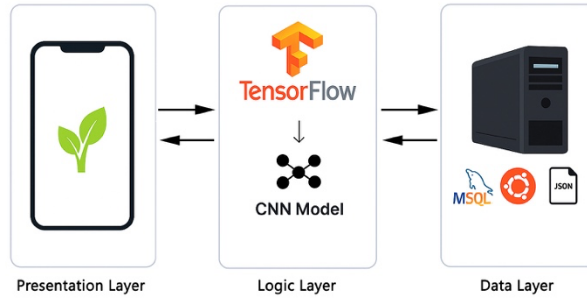


Fig. 1 System architecture

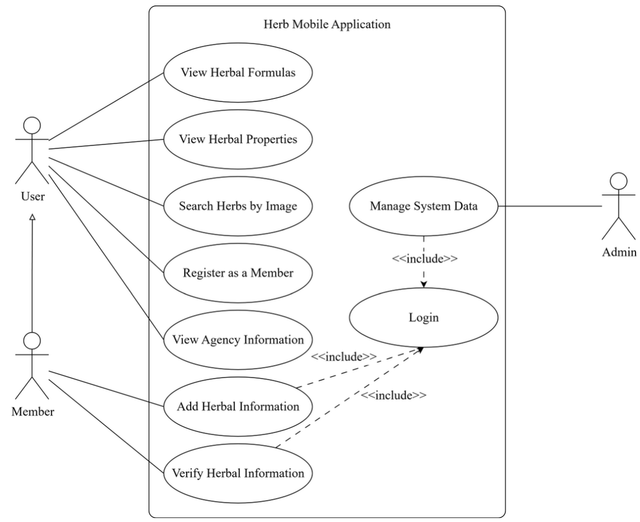


Fig. 2 Use case diagram for mobile application

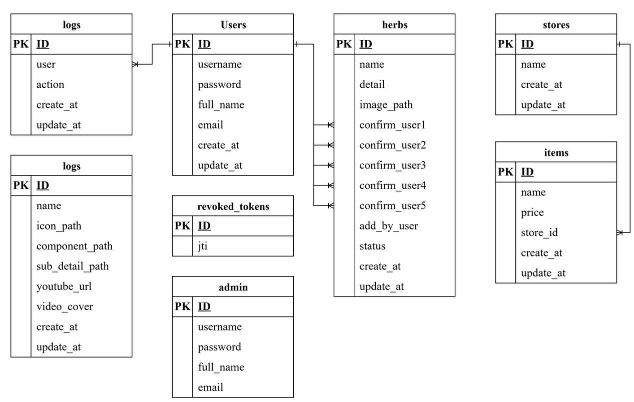


Fig. 3 Entity relationship for mobile application

Step 3 Coding: Pair Programming technique was applied by defining the roles of the developer as "Driver" and "Observer" to increase the inspection and reduce errors during programming [18]. The system was divided into 3 layers as designed: (1) Presentation Layer was developed in the form of a mobile application by using React Native as the development framework; (2) Logic Layer utilized a Convolutional Neural Network (CNN) model for processing herbal plant images which was developed on the TensorFlow platform and connected via Flask that was served as an intermediary connecting between the user's mobile application and the CNN model embedded on the server side; and (3) Data Layer utilized the MySQL database management system on the Ubuntu operating system and data were managed via phpMyAdmin.

Step 4 Testing: The prototype system was tasted under actual usage cases by dividing the testing into 2 parts as follows: Unit Testing and Acceptance Testing. For Unit Testing, it was conducted by 3 lecturers of Computer Technology with 10-year experience of teaching. Black-Box Testing technique was implemented to evaluate the overall performance of the system. As well as Acceptance Testing was conducted with a pilot group of 5 participants who were similar to the real sample group. Participants were allowed to access the system using their own devices and internet connections, with the development team offering guidance and support throughout the trial process. The results showed that users spent an average of 13.60 minutes learning the system, an average accuracy of the visual search function was at 92%, an average error rate was 2 times per user, and the satisfaction with usage was at a high level ($\bar{x}$= 4.2, S.D. = 0.45). The aims were to assess the system's readiness and fix shortcomings before testing it in a large sample group.

Satisfaction questionnaire

The satisfaction questionnaire was divided into 3 parts as follows: Part 1: general information of the respondents; Part 2: satisfaction level measurement questionnaire using a 5-point Likert scale [14, 15] covering 3 aspects as follows: (1) ease of use and accessibility; (2) system efficiency; and (3) quality and usefulness of the content; and Part 3: qualitative suggestions. The questionnaire was examined via Index of Item-Objective Congruence (IOC) [19] by 3 experts as follows: a lecturer in the Computer Technology Department and 2 officers who were responsible for Thai traditional medicine from the Public Health Office.

Data collection and analysis

Data collection

The data collection instrument was a questionnaire. The data gathered was classified into 2 categories: 1) quantitative (questionnaire sections 1 and 2) and 2) qualitative (questionnaire section 3). The data were collected over a three-month period. Additionally, the research team used public health office staff from 4 agencies in order to collect data. Before collecting data, the research team trained the staff on the using method of application, as well as generated a manual and a video which demonstrated the use of application. Each sample group received one month to test the application before answering a questionnaire to measure their satisfaction with the system. During such period, the staff offered helpful advice on the questions. When the data collection procedure of sample group concluded, the research team reviewed the data for correctness, completeness, and completeness. The data was subsequently investigated in order to draw conclusions.

Statistics used in data analysis

The data analysis from the questionnaires in this research was divided into 3 main parts as follows:

Part 1 involved the use of Descriptive Statistics analysis, applying the Mean and Standard Deviation to assess user satisfaction levels for each item. This approach assisted a clearer understanding of data trends and distribution patterns.

Part 2 aimed to analyze the relationship between the basic factors of the respondents and the satisfaction level using Non-parametric Statistics, namely, Mann-Whitney U test for comparing differences between two groups and Kruskal-Wallis H test for comparing between multiple groups. The selection of this method was based on the examination of the initial assumptions regarding Normality and Homogeneity of Variance. The examination results revealed that the data did not meet the assumptions of parametric statistics. Therefore, the analysis using non-parametric statistics was more appropriate in this study context.

Part 3 was the analysis of Qualitative Data which was obtained from user suggestions, implementing Frequency Distribution and mode consideration to systematically group and summarizing the most frequently repeated comments.

The satisfaction score levels can be interpreted as follows:

Level 5: 4.21 to 5.00, meaning Very High
Level 4: 3.41 to 4.20, meaning High
Level 3: 2.61 to 3.40, meaning Moderate
Level 2: 1.81 to 2.60, meaning Low
Level 1: 1.00 to 1.80, meaning Very Low

3. Results and Discussion

There are 3 objectives of this research. The result details are as follows:

Results of instructional media development

The results of teaching media development consisted of 30 traditional herbal recipes presented through 2 media formats as follows: video and graphics. The content demonstrated the steps of medicine preparation, properties, and usage with clear explanations, as shown in Fig 4.

Fig. 4 Herbal information infographic from the Thai-language mobile application

Discussion of the results of learning media development in multimedia form consisting of images, audio and video found that the sample group was most satisfied with the quality and usefulness of the content ($\bar{x}$ = 4.36, S.D. = 0.71). It reflected the appropriateness of the presentation format that helped learners understand the content more clearly, indicating that the use of various media formats promoted participation and continuity in learning, possibly because it was able to explain process information, such as how to prepare herbal medicine, in a sequential and easy-to-understand manner. So that, this is consistent with the research of Alhazmi [20] and Mahdi *et al.* [21], which demonstrated that the use of explanatory videos was more effective for learning compared to only text or audio. In particular, integrating videos with vocabulary information and definitions was shown to enhance learners' ability to retain words and comprehend their meanings more effectively.

The results of mobile application development

The application development results were applied on the Android operating system as shown in Fig 5 with 5 main functions as follows: (1) a home page showing 30 traditional herbal recipes in image and video format; (2) showing information on the properties of herbs with a search system by taking a photo or typing in the herbs' name by referring to 30 types of herbal plants in the database; (3) a function to add herbal information to the database where it has been mutually confirmed by 5 users; (4) demonstrating a system manual; and (5) displaying contact information for relevant agencies. In particular, the herb search function by image demonstrated the system efficiency in analyzing and identifying the types of herbal plants from images correctly. The results retrieved information on herbs that was identical with the images that users submitted to the system, along with details such as herb images, common names, scientific names, families, active ingredients, and medicinal properties. Examples of search results are shown in Table 1.

The discussion of application development results shows that the system is effectively applied for its intended purpose within the specified time frame, via performance evaluation by experts and technology acceptance from the pilot group. The success is possibly resulted from the software development process following the Extreme Programming approach, which emphasizes Pair Programming. Such program reduces errors during programming and increases the agility of continuous system improvement. This is in line with the findings of Popoola *et al.* [22] and Barros *et al.* [23], which indicated that the use of such an approach fostered collaboration between development teams and stakeholders, ultimately contributing to the production of higher-quality software.

Satisfaction results from a sample group

The satisfaction assessment results from a sample of 100 participants from Table 2 demonstrates that users are most satisfied with the application overall in all aspects. The aspect that received the very high average score was "quality and usefulness of the content" ($\bar{x}$ = 4.36, S.D. = 0.71). The sub-issue found that the item of "Satisfaction with the use of herbal information" with the highest average score ($\bar{x}$ = 4.63, S.D. = 0.65). The second most important item was "system efficiency" ($\bar{x}$ = 4.32, S.D. = 0.71), while "ease of use and accessibility" ($\bar{x}$ = 4.25, S.D. = 0.66). The item "ease of herbal search by image" received the highest score in this group ($\bar{x}$ = 4.36 S.D. = 0.67). For additional comments from 31 users, they were divided into 3 groups as follows: (1) Satisfaction with the usage (15 comments) (2) Suggestions for improving the system (7 comments) (3) Specific suggestions for adding functions in the future (9 comments). results are shown in Table 3. Furthermore, the results of relationship examination between the basic factor of participant and the overall satisfaction level revealed that "service area" was the only factor with a statistically significant impact on overall satisfaction ($p < 0.05$). In contrast, other factors—such as gender, age, educational level, and occupation—did not show statistically significant differences.

The result discussion of satisfaction evaluation with the application which was at a very high level in all aspects, especially in terms of content quality and usability reflects the system design that responds to user requirement. In particular, the herbal search function by image was evaluated at a very high level, which was possibly due to the application of artificial intelligence (AI) technology that increased accuracy and reduced the using steps. This is in line with the findings of Dagan *et al.* [24] and Hashmi [25], which indicated that visual information search improved user experience. In addition, the inferential analysis as well found that "service area" was the only factor with a statistically significant impact on overall satisfaction. It reflects the influence of geographic context on application awareness and usage in each area.

While the study yielded positive results, certain limitations should be noted. Its geographically limited scope may affect the generalizability of findings, and the modest, targeted sample may limit representativeness. Additionally, the evaluation focused on functionality and user satisfaction, without addressing long-term usage or environmental influences.

Fig. 5 Results of the mobile application (Thai version)

Table 1 Examples of herbal plant information captured and processed through the application

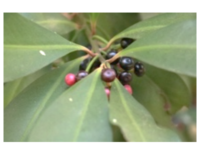
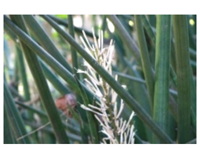
Image	Scientific name	Family	Key active compounds	Medicinal properties
	*Xiphidium caeruleum* Aubl.	Haemodoraceae	Saponins, Tannins Phenolics, Steroids Triterpenoids	The leaves are used medicinally to reduce inflammation in the urinary tract.
	*Cissus quadrangularis* L.	Vitaceae	Quercetin, Kaempferol, Rutin, Resveratrol	The stem is used in traditional medicine for the treatment of hemorrhoids.
	*Justicia valida* Ridl. var. *glandulosa* Fisch.	Justicia	Juaticin, Vitexin, apiginin and patentiflorin A	The leaves are traditionally used for the treatment of skin disorders.
	*Ardisia ionantha* K. Larsen & C.M. Hu	Primulaceae	α-amyrin, rapanone	The flowers are employed as an anthelmintic agent.
	*Sansevieria cylindrica* Bojer ex Hook	Asparagaceae	β-sitosterol, Hederagenin	Rhizomes are used to enrich the blood, act as anthelmintic agents.

Table 2 Satisfaction results from a sample group

Topics	$\bar{x}$	S.D.	Results
Aspect 1 Usability and Accessibility			
1. Ease of using mobile applications	4.28	0.60	very high level
2. Quick access to herbal information	4.15	0.61	high level
3. Satisfaction with user interface design	4.22	0.75	very high level
4. Convenience in searching for herbs using pictures	4.36	0.67	very high level
Average	4.25	0.66	very high level
Aspect 2 Performance			
5. Accuracy of data record and display	4.43	0.69	very high level
6. Speed of loading and system responsiveness	4.24	0.73	very high level
7. System stability (no crashes or errors)	4.30	0.70	very high level
Average	4.32	0.71	very high level
Aspect 3 Content Quality and Usefulness			
8. Completeness and accuracy of the herbal information received	4.40	0.68	very high level
9. Presentation of information in an easy-to-understand format	4.30	0.69	very high level
10. The interesting content presented and learning promotion	4.20	0.72	high level
11. Ability to apply herbal information to daily life	4.27	0.79	very high level
12. Satisfaction in using the information	4.63	0.65	very high level
Average	4.36	0.71	very high level

Table 3 Analysis of Results of User Feedback

Categories	Number
Satisfaction with the use	15
Improvements necessary	7
Additional features	9

4. Conclusion

This research aims to develop a mobile application by implementing Artificial intelligence technology and teaching media in the form of images and video infographics to promote the local herb learning via information search by image and user participation in adding herbal information. The results revealed that the application effectively responded to users' learning, with users being most satisfied in very high all aspects and with significant differences in satisfaction levels between service areas. This may be attributed to the current system limitation, in which the content is presented in a fixed and uniform format. It reflects the need to design or adapt the content to be suitable for the context of each area. Therefore, in the future development approach is proposed by creating a module to recommend herbal recipes based on individual symptoms of users, along with expanding the platform to iOS and websites to increase access channels for a wider range of users. Furthermore, expanding the use and transferring Thai herbal wisdom is favorably proposed to the international level. This research is a prototype of the application of artificial intelligence technology in tangible learning in community-level. The research reflects a creative scientific approach by combining ethnobotanical data with digital innovation to develop an accessible, user-friendly application tailored for Thai users, highlighting its potential for community impact.

5. Acknowledgement

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6. Declaration of generative AI in scientific writing

We used a generative AI tool solely to assist literature searches and to check grammar and linguistic clarity.

7. CRediT author statement

Attapol Kunlerd: Conceptualization, Methodology, Software, Validation, Investigation, Writing – Original Draft, Writing – Review & Editing

Atipat Rithiron: Supervision, Project Administration, Visualization, Investigation

Boonlueo Nabumroong: Conceptualization, Software, Validation

Sakchan Luangmaneerote: Software, Validation

Anyawee Chiwachirakhampon: Conceptualization, Formal Analysis, Software, Validation

Jakkrit Kaewyotha: Conceptualization, Methodology, Writing – Original Draft, Writing – Review & Editing

8. Research involving human and animals rights

The study complied with ICH-GCP and institutional guidelines for the ethical conduct of human research. All procedures minimized risk and preserved confidentiality. All participants provided informed verbal consent prior to data collection. No animal subjects were involved.

9. Ethics Approval and Consent to Participate

The protocol was reviewed by the Human Research Ethics Committee, Rajamangala University of Technology

Isan, and granted an exemption (Certificate of Exemption; Project Code HEC-03-63-009). All participants provided informed verbal consent before participation.

10. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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