APPLYING HUMAN-CENTERED DESIGN FOR GAME DEVELOPMENT TO PROMOTE THE LOCAL WISDOM OF INDIGO-DYED FABRICS PRODUCTION

Supawadee Suwannathen and Ratanachote Thienmongkol[*]

Faculty of Informatics, Mahasarakham University,
Maha Sarakham 44150, Thailand

[*]*Corresponding author: ratanachote.t@msu.ac.th*

Abstract

This study aims to develop an interactive game to promote the local wisdom of natural indigo dyeing as a unique cultural characteristic of Sakon Nakhon Province, and to create a new approach of learning local wisdom that corresponds with modern instructional models. The conceptual framework for this research was applied from the Human-Centered Design concept. The guide to the media development, contents, and game condition, were theoretically community-based in which the game design was directly engaged with the stakeholders comprising: Group 1: a pilot community of natural indigo and color dyeing, academicians, media design specialists, indigo dyeing specialists; and Group 2: young volunteers joining the game test and media assessment specialists. Data was collected via questionnaires, interviews, field observations and a learning evaluation test. Statistics used in the study were frequency, percentage, mean and standard deviation. After the media assessment and game test had been conducted with the specialists and volunteer game players, it was concluded that the game quality was rated at a good level, while the players' satisfaction was at a very high level. The media component received a high level of satisfaction; the highest being in the category *Interaction with users*. Furthermore, the volunteer game players gained better knowledge of natural indigo dyeing with an Effective Index (E.I.) of 0.7987 or 79.87%.

Keywords: Community-based game; natural indigo game development; Human-Centered Design

Introduction

Indigo dyed fabric is a major product of the local community in Sakon Nakhon Province, Thailand, in which indigo is extracted from indigo trees, a shrub plant that belongs to the pea family. In other words, the practice of local wisdom in preserving indigo dyed fabrics is becoming more prevalent among the local community in Sakon Nakhon. Previously, almost all local families commonly produced indigo dyed fabric for their own use, since its color is vivid and never fades, and the material is readily available. However, due to technological advances over time, the fabric can currently be produced by machines more conveniently, cheaply, and quickly, but with increased vividness and variety of eye-catching patterns. Accordingly, the popularity of indigo hand-dyed fabric has decreased gradually and seems to be disappearing from local communities (Saithong, 2002).

In particular, the production of natural indigo dyeing is an exacting and complicated process-starting from preparing indigo paste, dyeing, and designing the patterns that have eventually become part of the culture. Natural indigo dyeing is likely an intergenerational cultural activity, with characteristics in relation to identity defined within the body of knowledge of the making of indigo, as well as other related processes. Consequently, indigo dyeing has been broadly accepted and constantly promoted via several research works. In this regard, government organizations in Sakon Nakhon have lately been encouraged to create research and academic services on indigo dyeing, with an aim to assemble the knowledge from the local officials and other associated organizations outside the province, and to support indigo-dyed fabric manufacturers from the upstream to downstream. Basically, the research and academic services should be based on scientific principles integrated with local wisdom, and then provided to the members of local communities so that indigo-dyed fabric can be reproduced with better quality and achieved popularity (Saithong, 2015).

Nevertheless, the dyeing production is very complicated, so most of the manufacturers are only the senior masters within the communities who carry out

indigo dyeing as an extra job after farming. In contrast, their children, after graduating from high schools, indicate interest in major cities for employment opportunities (Saithong, 2015). This exodus from cultural processes is ongoing, though there has been an effort to form relevant clubs and to teach about indigo dyeing in schools; but this is only practical for a short run of production. One of the critical problems is that instructional media is outdated, such as brochures, handbooks, documentary videos, and press releases. Despite the several online approaches used, there is no interaction that will engage a user as part of the media, so it remains unattractive (Sripasuda et al., 2018). At this point, the gap between local wisdom and young generation must be fulfilled so the teenagers will be encouraged to learn more about their local wisdom in an enjoyable manner.

Based on the above, the researcher aimed to develop a community-based simulation game for the local way of life to become a learning media enhancing the users' understanding of natural indigo dyeing. The media was creatively designed and combined with the pilot community for natural indigo and color dyeing. This game development was also supported by the research works on using game for education, in which the findings indicated that enjoyment and entertainment perceived from the game efficiently stimulated the players' interest to learn, improve, and repeat their skills (Supphakhun, 2015; Pakpaern, 2016). Accordingly, developing games as instructional media to promote the local wisdom for local communities could encourage the players' curiosity and recognition of the wisdoms of local communities. Namely, these local wisdoms are likely to lay the groundwork for preserving and fostering Thai wisdom to match with the learners' behaviors in a modern era, as well as using as an educational medium (Chesamae et al., 2017). In addition, the role of the developed community-based simulation game would bring young people invaluable insights into their traditions and practices of indigo dyed fabrics. As a result, the researchers aimed to conduct the study: 1) to explore the process of natural indigo dyeing based on a Human-Centered Design; 2) to develop an interactive game to promote the local wisdom of natural indigo dyeing; and 3) to assess the players' learning outcomes after experiencing with the game.

Materials and Methods

Research Methodology

In this study, the researchers applied a key concept of community-based learning to explore the community context regarding indigo dyeing, and to apply local wisdom as the background knowledge for the game design. Additionally, the conceptual framework was based on Human-Centered Design (HCD) (Thienmongkol and Waring, 2012) and consisted of six phases as illustrated in Figure 1. With this HCD, the conceptual framework has been implemented with many pieces of community-based research works, and provided the results that matched with the needs and problems of the target group. At this point, the conceptual framework comprised six phases that were clearly defined, including the literature reviews on the target group, as well as the target group's measurement, where all feedbacks were analyzed to solve the designing problems before achieving the final design. Accordingly, this conceptual framework was suitable for community-based research, since its process was clearer and more applicable than the former, HCD: ISO 13407 with a three-phase process: Inspiration Phase, Ideation Phase, Implementation Phase (ISO 13407, 1999).
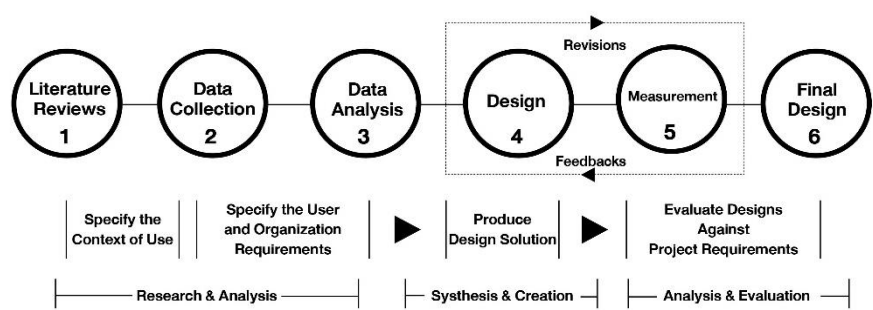

Figure 1: Research Methodology

Phase 1: Literature reviews purposively focusing on the local wisdom of indigo dyeing, game development, Human-Centered Design theory, and community-based learning.

Phase 2: Data Collection - the researcher constructed several suitable research tools to collect the data from the pilot communities, the specialists in media design and indigo dyeing as the stakeholders for the game design.

Phase 3: Data Analysis - During the pre-production stage, several techniques were used including: 1) Content analysis for data analysis was drawn from the literature reviews, the fieldwork observation, and the interviews with the key informants; 2) Typological Analysis was drawn to analyze the data from the in-depth interviews with the key informants to identify keywords or word clusters related to one another; 3) Frequency Analysis was used to analyze the responses from the key informants to define the mean scores of principles and methods of natural indigo dyeing; and 4) Triangulation Analysis was employed to synthesize all data from Phase 1 to construct the key concept for game design and development, with the results being validated with data triangulation.

Phase 4: Design - the findings from the previous phases were analyzed to define the game concept and to design the inactive game for instruction on the wisdom of natural indigo dyeing. In this phase, the well-planned game model was created and required further assessment of implementation feasibility.

Phase 5: Measurement - the specialists assessed the game quality and feasibility. The experimental session was carried out with a sample group of young volunteers in Sakon Nakhon whose learning outcomes and satisfaction were later assessed. After that, the researcher analyzed the results after the game assessment and the players' satisfaction evaluation using different variables and mean scores with specific interpretation scores (4.51-5.00 = Highest, 3.51-4.50 = High, 2.50-3.50 = Moderate, 1.51-2.50 = Low, and 0.00-1.50 = Lowest). This step was followed by counting the frequency and percentage score to classify the total data as well as evaluating each of the question items with different topics. Later, the players' learning outcomes were analyzed to define Effective Index (E.I.). Finally, the findings from Phase 5 was validated and revised to create the game with better components.

Phase 6: Final Design - the specialists' feedbacks after game assessment were used to revise the game for its final version before implementation.

Population and Sample Group

The sample group for data collection was divided into two groups through purposive sampling as described below.

Group 1: The sample group for data collection on indigo dyeing production.

1) The pilot community for natural indigo and color dyeing was situated in Sakon Nakhon province, Thailand, and consisted of four communities: 1) Tambon Panna Natural Color-Dyed Fabric Weaving Community enterprise; 2) Ban Kam Kha Indigo-Dyed Fabric Weaving Community enterprise; 3) The Women's Fabric Weaving Community enterprise 2 at Amphoe Akat Amnuai, Sakon Nakhon; and 4) Amphoe Song Dao Natural-Dyed Cotton and Silk Community enterprise. These communities were qualified through a project on the development and enhancement of the individual skill for natural color dye and indigo use in diversified industries in the ASEAN hub.

2) Academics: The specialists in natural indigo dyeing

3) 30 young volunteers who were interested in natural indigo and color dyeing process whose information was collected for game development and design.

4) Five media design specialists selected by purposive sampling.

Group 2: The sample group for the interactive game implementation including 30 young volunteers living in Sakon Nakhon and five specialists for the game quality assessment, including two specialists for the game content assessment, two specialists for the game development assessment, and a specialist for the game design assessment.

Research Tools and Data Collection

1) Field-work observation forms were used to observe the situations in the four pilot communities in Sakon Nakhon province, as well as the activities performed by the community members.

2) Semi-structured interview forms were used to collect the information from the members of the pilot communities in terms of natural indigo dyeing, the academics, the specialists in indigo dyeing, and the specialists in media design.

3) Questionnaires were used to identify if the community members were in need of further game development, and to collect more information from the teenagers in the pilot communities.

4) The assessment form was provided for the specialists to assess the media quality.

5) Learning outcome evaluation form was used to collect the information from the young volunteers in Sakon Nakhon province.

6) The evaluation form was used to evaluate the satisfaction of young volunteers in Sakon Nakhon province towards the developed game.

The research instruments were tested for its validity by 5 experts in different related fields while the Index of Item Objective Congruence was found to be averagely from 0.6-1.0. These affirmed that the instruments were applicable for the study.

Results and Discussion

Applying the HCD into the game design helped the researcher focus more on the target group, whose needs were to learn about the process of natural indigo dyeing, by allowing them to participate in the activity, rather than the data collection alone. Those six phases of the conceptual framework consisted of: 1) Literature Reviews; 2) Data Collection; 3) Data Analysis; 4) Design; 5) Measurement; and 6) Final Design. It helped the researcher gain a broader insight through the target group's brainstorming and the technology use, so what they needed could be realized and able to practically work and interact with the users. Above all, it was applicable and accessible for all users.

Pre-Production Data Analysis

Based on the data collection and analysis in Phase 1, the game for promoting the wisdom of natural indigo dyeing should be able to function on android-based smartphones. It is a strategy game, so that the player can learn by planning their own strategy for making natural-indigo dyed fabrics. The game content was classified into different levels as follows:

Indigo Tree Planting - An indigo game tree should be planted on the upland with regular watering; too much water should be avoided. All weeds

should be cleared off so the tree can be fully exposed to the sunlight. The game content also includes some tips, including: 1) There are two kinds of indigo, straight pod and curved pod, that require different methods of harvesting; 2) Indigo dislikes wetness but requires regular watering; with wetness, its leaves will wither and fall off; and 3) After four weeks of growth, all weeds need to be cleared off for the indigo sprouts to reach the sunlight.

Indigo Harvest - It should be harvested in the morning before the sun rises. Again, the game content includes some tips: 1) The harvesting should be done in the early morning before the sun shows up; harvesting in the late morning with strong sunlight, the indigo leaves would dry and give low-quality color; 2) The harvester should be dressed in a sealed costume since the indigo leaves can cause itches.

Making of Fresh Indigo Liquid - This happens after gathering and making bunches of the indigo leaves and soaking them in a water-full container. The soaked leaves will be pressed with a heavy object to keep them from floating. As in other levels, the game content includes a tip - 'after having been soaked for 10 hours, the leaves should be turned upside down and again left in the water for another 10 hours. Then, it will be ready for making the indigo liquid.'

Indigo Paste Preparation - This step comes after collecting the indigo liquid and then mixing by a stirring fork with 10 grams of lime (Calcium Hydroxide) and 1 liter of fresh water. The tip is also given that - 'During this step, all the mixtures should be stirred constantly until the color becomes dark blue and then all bubbles will swiftly disappear.'

Making of Ash-Mixed Water - Ash will be soaked in a container with holes or pounded coconut shell at the bottom. The holes at the bottom will be filled up with either sponge or coconut coir. Then, the water will be filtered off and the container will be refilled with water. All filtered water will be mixed to produce the ash-mixed water for making an indigo dyeing pot. The tips in this level are: 1) The good plants for making ash are banana trunk, coconut-leaf stalk, cotton pod; and 2) The suitable ash-mixed water must be obtained and mixed from two water filtrations.

Making of Indigo Dyeing Pot - This is a step of preparing the indigo dyeing liquid that requires several materials, including 1 kilogram of indigo paste, 3 liters of ash-mixed water, and 3 liters of tamarind mixed water (100-gram tamarind paste/ 3-liter water). All the materials will be mixed together. It is necessary to "Jok" or to daily scoop up and pour down the dyeing liquid in the pot (twice a day – morning and evening). This activity will be repeated for 4-7 days and the liquid will turn green-yellow, which is suitable for dyeing cotton fibers. Some tips are again given: 1) To "Jok" means adding more oxygen into the pot by scooping up and pouring the liquid in the pot; 2) To observe if the indigo already has suitable color, the dyeing liquid should be green-yellow. The next is **a dyeing step** of dipping a bunch of cotton fibers into the pot (the optimum depth for dyeing is from upon the surface to the midst of the pot). After that, the dyed cotton should be rest and exposed to the air for 15 minutes before washing in fresh water. The tips for this step are: 1) The cotton fiber should be soaked in the dyeing liquid at the midst of the pot; 2) While being dyeing, the cotton fiber must be kept from air; and 3) For darker color, the cotton fiber should be soaked and dyed in three pots or more. After dyeing, the next step is **the indigo dyeing pot preservation,** i.e. to preserve the indigo liquid in a ready state for the next dyeing without making a new pot. On this matter, a good dyeing ratio for a bunch of cotton fiber requires the following materials: indigo paste (100 grams), ash-mixed water and tamarind-mixed water (100 milliliters), and brown sugar (20 grams). The tips for this step is: 1) the pot preservation is to add more of the materials into the pot after either the latest dyeing, or when there is no need of dyeing, in order to feed up the bacteria in the pot; 2) It is necessary to "Jok" the pot every day in order to add more oxygen into the pot so it will be ready for the next dyeing; and 3) the material to be added must be consistent with the quantity of the cotton.

The field observation data - According to the field observation on the on-site visit for data collection with the sample group and the interview with the indigo community chairperson, the results from the production steps, procedure, ingredients, and materials were corresponding to the data collection in Phase 1 where the community regularly produced their natural indigo dye from local

materials commonly found within their community as well as using the natural ingredients. Meanwhile, all steps of the natural indigo dyeing process including Indigo Tree Planting, Indigo Harvest, Making of Fresh Indigo Liquid, Indigo Paste Preparation, Making of Ash-Mixed Water, Making of Indigo Dyeing Pot, and the dyeing pot preservation, were strictly performed following the knowledge body and local wisdom inherited from their ancestor.

The content of Indigo Game was classified into several levels, including Indigo Tree Planting, Indigo Harvest, Making of Fresh Indigo Liquid, Indigo Paste Preparation, Making of Ash-Mixed Water, and Making of Indigo Dyeing Pot completely, covering all processes for natural indigo dyeing. The result was consistent with the studies by Saithong (2002) and Songleknok (2015) in which indigo dyeing is the knowledge people inherited from the ancestor and comprises several sub-topics, including indigo seed, indigo tree planting, indigo harvesting, the making of indigo paste, the making of indigo dyeing pot, cotton fiber preparation for dyeing, dyeing pot maintenance, basic knowledge of salty alkaline water suitable for the making of dyeing pot in which the plant selection needs to be suitable for the making of alkaline water; this alkaline water is called "ash-water" in some areas. The main material for natural indigo dyeing can be simply found in local natural resources and this knowledge has been built through repeated actions which finally become assimilated as personal skill or proficiency.

Game Prototype

Indigo Game was designed by simulating the local way of life of the indigo dyeing communities that presented all the steps of indigo dyeing from planting indigo tree to producing the indigo-dyed cotton. The buildings and structures were neatly designed to represent Isan lifestyle, along with sound effects for different situations and background music changing in different scenes throughout the game. The overview of the game is illustrated in Figure 2, showing that the game engaged a user in all processes as he/she was able to interact by clicking, dragging, or moving the objects in the game to achieve the desired goal or outcome.

Figure 2: Final Version of Game Prototype

The interactive feature design in Indigo Game aimed to activate the users' learning of the local wisdom of natural indigo dyeing process so they could develop personal skills in the same manner of practical performance. To do so, the researchers allowed the users to learn and practice indigo dyeing skill by the finger touch feature on the Indigo Game on smartphones. This feature was called the Finger Skill Model, and was similarly performed as a real skill model, so the users could learn the natural indigo dyeing process without practical involvement. This model specified that all skills could be developed through practice. Hence, while the user had not had a chance to engage practically, the game simulated all features from the real environment and procedures to prepare the users with the necessary skills and cognitive processes to learn each specific knowledge comprehensively. This Finger Skill Model was illustrated in Figure 3.
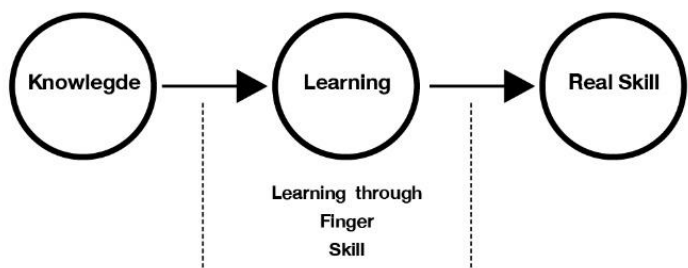
Figure 3: Finger Skill Model

The game design was also based on a concept of Finger Skill that was similar to the Real Skill conception, in which the researcher allowed the users to drag their finger to flip a bunch of indigo by the due time after soaking. Then, the users drag their fingers to remove the leftover indigo off the soaking container before adding more materials into the pot. Then, the users use a stirring fork by moving their finger in the same direction as the actual indigo stirring movement, as seen in Figure 4. Another sample of the finger skill-based game design was mentioned in the making of indigo dyeing pot (Figure 5), which allowed the users to drag their finger to move all materials and mix them in the pot. Additionally, during the step of "Jok" (scoop up and pour down) to add more oxygen into the pot, the users needed to execute it correctly and daily, so the researcher also created the finger skill-based feature for them to move a bowl with their fingers to fetch the water from the pot and pour it back again as illustrated in Figure 6.

Figure 4: Indigo Stirring Process

Figure 5: The Making of Natural Indigo Dyeing Pot

Figure 6: Scooping up and Pouring down Indigo Paste (Jok)

Game Prototype Measurement

Table 1: Mean and Standard Deviation from Specialists' Assessment on Game Prototype

Game Components	Game Prototype Quality			Satisfaction		
	$\bar{x}$	SD	Level	$\bar{x}$	SD	Level
1. Content	4.03	0.65	Good	4.24	0.46	High
2. Design	3.87	0.51	Good	4.31	0.67	High
3. User's interface	3.70	0.48	Good	4.61	0.53	Highest
Total	3.87	0.54	Good	4.40	0.52	High

From Table 1, the specialists' evaluation on the game prototype showed that the overall quality was good ($\bar{x}$ = 3.87, SD = 0.54). When separately considering each component, game content had good quality and was rated with the highest mean score ($\bar{x}$ = 4.03, SD = 0.65). Similarly, the users' overall

satisfaction toward the game prototype was very high ($\bar{x}$ = 4.40, SD = 0.52). The user's interface was the most satisfactory ($\bar{x}$ = 4.61, SD = 0.53).

Learning Outcome Analysis After Using the Game Prototype

Table 2: Effectiveness Index of Game Prototype

Number of Media Users	Product of Student's Number and Total Score	Total Post-Test Score	Total Pre-Test Score	E.I.
30	300	268	141	0.7987

Table 2 indicated that the sample group after playing the Indigo Game developed better comprehension on natural indigo dyeing in which Effective Index (E.I.) of their learning outcomes was totally 0.7987 or 79.87 percent. This firmly indicated that after playing Indigo Game, the young users' learning outcomes gained more knowledge of natural indigo dyeing, which was similar to the previous studies on learning via the games, where it encouraged the learners to learn and practice individual personal skills from simple problems toward the more complicated ones. For example, after any users failed to accomplish the goal, the game system would present demonstration videos for them to learn, as shown in Figure 7. Within this system, the learner's skill score after learning with the game was significantly higher than their previous score (Pakpaern, 2016). The fact was that learning with game fostered the learners' memory of their learned lessons. They would learn from their own decision-making on different situations in the game, and understand difficult and complicated content without feeling bored. This could be confirmed with the user's satisfaction result toward the Indigo Game, which was rated as a high level (Samranwong et al., 2017). Apparently, presenting lessons through games arouse the learners' interest and participation, as well as help them review the lessons competently. Also, they could learn via the game at any time, so the learning process also existed outside of classrooms or trainings (Supppakhun, 2015). Moreover, practicing with the Finger Skill model was likely a practical tactic for the learners, in which they could gain knowledge and skill without practical hands-on experiences.

Figure 7: Indigo Dyeing Process Video

Conclusion

The development of a simulation game to promote the local wisdom of natural indigo dyeing, called "Indigo Game", was based on community-based learning and Human-Centered Design. The findings from the data collection on the needs for the game, and the interviews with the specialists in game content and media design, were processed through triangulation analysis and resulted in the process of indigo dyeing being classifying into different levels in the game. Indigo Game is a strategic game for a player to make a perfect plan for indigo dyeing, and to employ time constraints in order to successfully complete the missions in the game. This simulation game works on the android smartphones via a 2D display in which the game content has been designed to fit the phone's operation system with quick access, so that a player can gain knowledge from the game by getting through each level of entertainment.

The quality assessment of Indigo Game was rated at a high level and the players' satisfaction was at a very high level. In the same vein, the data analysis on the player's learning outcome suggested that those who play the game have developed better knowledge of natural indigo dyeing. Furthermore, they are able to develop their skills in natural indigo dyeing by playing the game, as well as practice with the Finger Skill Model which is similar to a real skill model, so they can at the same time improve knowledge of skills while learning, though they do not practically perform the real indigo dyeing process.

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