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Model of Crowd Context-Based Learning via IoT Wearable Technology to Promote Digital Health Literacy

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Abstract

The global pandemic of coronavirus disease 2019 (COVID-19) demonstrates the urgent need for digital instructional system design to facilitate digital health literacy for citizens in a ubiquitous healthcare ecosystem. This research aimed to propose the Model of Crowd Context-Based Learning via IoT Wearable Technology (CCBL via IoTW Model). The research objectives were to synthesize and evaluate the suitability of the CCBL via IoTW Model to promote digital health literacy. This study employed Mixed-Method Research (MMR), which collects and analyzes both qualitative and quantitative data. The results show that: (1) The CCBL via IoTW Model has 4 components: 1) Input Factors, 2) IoTW-Driven Learning Processes, 3) Digital-Driven Assessments, and 4) Data Visualization and Real-Time Feedback; (2) All the experts agreed that the CCBL via IoTW Model is suitability for promoting digital health literacy and health behavior change of the citizens towards bio-digital citizenship in a ubiquitous healthcare ecosystem through digital health intervention in the future at a very high level ($\bar{x}$ = 4.76, S.D.= 0.43).

Keywords: Crowd Context-Based Learning, IoT Wearable Technology, Digital health literacy, Instructional system design

Introduction

Digital health technologies have been highlighted as viable methods to solve problems arising during the epidemic of coronavirus disease 2019 (COVID-19) [1]–[3]. The global pandemic of COVID-19 has generated an urgent need for cross-sectoral coordination in the digital workflow to respond to the epidemic [1]–[3],[6]. Moreover, rapidly evolving evidence-based practice, shifting medical guidelines, misinformation, and problems in online COVID-19 vaccine registration to immunizations, and accessing health services in the hospital and clinical pharmacy have created new challenges to find a sustainable solution, resource mobilization, and facilitate citizens' digital health literacy [1]–[4].

The 2030 Agenda for Sustainable Development Goals (SDGs) was approved by all UN Member States in September 2015, with 17 goals and 169 targets to be fulfilled by 2030; It was a rallying cry for all countries to urgently take action to create revolutionary change for people, planet, peace, and prosperity. [5]–[6]. Includes public-private partnerships (PPPs) focused on promoting health literacy through active operations for achieving the SDGs in Goal 3 to promote healthy lives and promote well-being, and Goal 4 to enhance inclusive and equitable quality education and promote lifelong learning for all [3], [5]–[6].

Digital health literacy is an evolving of health literacy towards e-health literacy and digital health literacy [1]–[3],[7]–[8]. Moreover, It is an essential learning outcome as an individual's ability in the digital era that encompasses the knowledge, skills, and attitudes concerning reading and writing to adopt and adapt to ever-changing digital technologies [2]–[3]. It encompasses aspects of health dimensions of health promotion, health prevention, and healthcare, which each dimension will have four critical indicators– accessibility, apprehensibility, appraisibility, and applicability of the health information via digital devices in health systems [8]–[10].

Due to the people's digital health literacy of large numbers in low-, and middle-Income countries are insufficient to manage the demands and complexities in dimensions of health promotion, health care, and

disease prevention [2], [11]–[12]. Thus, educational and public health organizations need resource mobilization to instructional design for facilitating and promoting digital health literacy also positive health behaviors based on the efforts to define and characterize digital citizens towards bio-digital citizenship [4]–[5], [10]–[13].

The current state of contemporary health policy renders citizens held responsible for their health through digital technologies in digital health citizenship. While bio-digital citizenship is a term meant to convey the possibility of digital citizenship towards bio-digital citizenship through utilizing the advanced technology and biomedicine opens up new avenues to learn, interact, and use biological data and real-time feedback based to be empowered and for social systems to be interconnected, safe, and conducive to people's health and well-being [10],[13]–[14].

The science of Instructional System Design (ISD) based on the Systems Approach (SA) in the digital era is to propose, select and use a generic or specific model in contextually practice for analyzing, designing, developing, managing, and evaluating the learning innovations [15]–[19]. Learning innovation as an intervention aims to evoke the flexible and appropriate cognitive, social, and teaching presence in a human-centered and goal-oriented approach regarding efficiency during the learning process and effectiveness of learning outcomes [9],[20]–[24]. Thus, the practice in the landscape of ISD in the digital contexts to support lifelong learning encompasses resource mobilization, learning theories, learning strategies, and emerging media symbol systems in the digital era demonstrates the need concerning integrating Technological Pedagogical Content Knowledge (TPACK) towards lifelong learning for all [16], [25]–[27].

Nittayathammakul, Chatwattana, and Piriyasurawong (2021) [28] presented the conceptual framework of crowd context-based learning via IoT wearable technology to promote digital health literacy. The conceptual framework has four elements: 1) cybergogical approach, 2) technological approach, 3) learning experience design and 4) learning outcomes assessments. The highlight of this conceptual framework is the integration between the cybergogical approach and the technological approach.

According to the problems, principles, theories, and related research mentioned above, we are interested in synthesizing and evaluating the suitability of the model of crowd context-based learning via IoT wearable technology to promote digital health literacy. We anticipate that our model could be used for suitable and available resource mobilization for sourcing, orientating, facilitating the IoTW-Driven Learning Processes to promote digital health literacy.

Research Objectives

The research objectives of this study were:

1) To synthesize the Model of Crowd Context-Based Learning via IoT Wearable Technology (CCBL via IoTW Model) to promote digital health literacy.
2) To evaluate the suitability of the CCBL via IoTW Model to promote digital health literacy.

Literature Review

Health Education Standards

Internationally recognized health education standards are both a prerequisite and a metric for attaining the SDG in well-being and lifelong learning. [3], [5]–[6]. The Health Education Standards were developed by the

National Center for Chronic Disease Prevention and Health Promotion, the United States of America (USA) [29] consists of 8 standards:

1. Standard 1; learners will comprehend concepts related to health promotion and disease prevention to enhance health,

2. Standard 2; learners will analyze the influence of family, peers, culture, media, technology, and other factors on health behaviors,

3. Standard 3; learners will demonstrate the ability to access valid information, products, and services to enhance health,

4. Standard 4; learners will demonstrate the ability to use interpersonal communication skills to enhance health and avoid or reduce health risks,

5. Standard 5; learners will demonstrate the ability to use decision-making skills to enhance health,

6. Standard 6; learners will demonstrate the ability to use goal-setting skills to enhance health,

7. Standard 7; learners will demonstrate the ability to practice health-enhancing behaviors and avoid or reduce health risks,

8. Standard 8; learners will demonstrate the ability to advocate for personal, family, and community health.

Moreover, several studies have reflected that curriculum, instruction, and assessments in the digital era should adapt and adopt new learning content and technologies in ISD processes to promote digital health literacy [1]–[3],[9], [30]–[32].

Digital Health Literacy (DHL)

DHL is a necessary learning outcome for citizens in the digital era towards digital citizenship and bio-digital citizenship [3], [10],[13]–[14]. Generally, DHL is the personal ability to access, apprehend, appraise, and apply digital health information from digital communication technologies in both dimensions of health promotion, health care, and disease prevention [2]–[3]. Thus, popularly recognized digital health literacy assessments are characterized as DHL assessments based on the matrix between dimensions and indicators of DHL applied to global health systems [8]:

1. 3Ds-Dimensions of DHL as a horizontal axis consist of 3 significant behavioral dimensions: 1) D1-Healthcare refers to the ability to access information on medical or clinical issues, to understand medical information, to interpret and evaluate medical information, and to make informed decisions on medical issues and comply with medical advice, 2) D2-Disease prevention refers to the ability to access information on risk factors for health, to understand information on risk factors and derive meaning, to interpret and evaluate information on risk factors, and to make informed decisions on risk factors for health, and 3) D3-Health promotion refers to the ability to regularly update oneself on determinants of health in the social and physical environment, to comprehend information on determinants of health in the social and physical environment and derive meaning, to interpret and evaluate information on determinants of health in the social and physical environment, and the ability to make informed decisions on health determinants in the social and physical environment.

2. 4As-Indicators of DHL as a vertical axis consist of four significant behavioral indicators: 1) A1-Accessibility refers to the ability to seek, find and obtain digital health information to health; 2) A2-Apprehensibility refers to the ability to understand or comprehend the digital health information that is accessed; 3) A3-Appraisibility refers to the ability to interpret, filter, judge and appraise or evaluate the digital health

information that has been accessed; 4) A4-Applicability refers to the ability to communicate, use, apply digital information to make a decision-marking to maintain and improve health.

Each of these dimensions and indicators of digital health literacy represents an alignment concept of reading and writing to adopt and adapt to digital technologies in the health ecosystem requires specific cognitive processes and depends on the quality of the information received from the educational, social, and public health system [3]–[4],[8]. Moreover, several studies have reflected that adopting or adapting the DHLA in real life must consider the economic, social, and environmental context and the aims of adverse health problem-solving or promoting positive health behavior towards the citizens' health outcomes in different age groups and areas [8]–[11].

Crowd Context-Based Learning (CCBL)

CCBL is an innovative cybergogical approach that combination between crowd-based learning and context-based learning. CCBL focuses on self-directed and collaborative learning under a ubiquitous ecosystem through issues based on real-life situations with crowdsourcing platforms to promote motivation, human cognitive process, decision making, and well-being in terms of positive mental and physical health in the digital world, which educational management stakeholders need operating through resource mobilization to sourcing, orientating and facilitating learners to learn in seamless learning environments effectively [3],[10],[13],[33]–[37]. Moreover, several studies found that the benefits of crowd-based learning and context-based learning are activated into the components of digital health literacy also enable foster digital health literacy [3],[33]–[38].

IoT Wearable Technology (IoTW)

IoTW is an innovative technological approach that combination between IoT technology and wearable technology. Thus, IoTW is an emerging technology that describes not only the view of a larger-scaled network in the level of Wireless Wide Area Network (WWAN) but also Wireless Body Area Network (WBAN) in the small-scaled network that operates via a microcontroller, processing units, and advanced sensor technology in ubiquitous environments. However, IoTW focuses on supporting users to connect, enabling, browse, track, and monitor self-bio feedback via Graphic User Interface (GUI) to promote attention, perception, comprehension, decision-making, and meta-cognition in terms of health monitoring, health communication, and self-management [13],[39]–[42]. Moreover, several studies found that the benefits of IoT technology and wearable technology are activated into the components of digital health literacy also enable foster digital health literacy [3], [39]–[42].

Digital-Driven Assessments (DDA)

In both formal and informal learning, authentic assessment is critical agenda. [43]. Digital technology has the potential to be used to support the assessment of knowledge, skills, and attitudes like literacies, competencies, and digital footprints in education concerning real-life situations [2], [24], [43]. In particular, mobile and wearable devices allow the learners to foster interactions with physical objects and various environments (indoors and outdoors) [43]. These interactions can be monitored and automatically assessed in a way that is similar to traditional objective tests [24],[43]. Self-assessment, peer-assessment, bio-assessment, and physical assessment can be meaningful types of diagnostic-, formative-, and summative assessment [10],[13]– [14], [43]–[44]. It is critical to digital instructional designers' ability to adopt specific educational standards in designing the Digital-Driven Assessments (DDA) to be measured learning outcome variables based on components and indicators of the operational definitions also digital act and check for learning progress, learning footprints, and learning achievement [24],[43]–[45]. Utilization of suitable and

available digital technology for a successful implementation for assessing learners' performance about the standards related to the components and indicators of learning outcomes [3],[10],[13]–[14],[30].

Research Methodology

The research methodology used in this study is mixed-methods research according to the exploratory sequential design [46] aiming to investigate and propose the Model of Crowd Context-Based Learning via IoT Wearable Technology (CCBL via IoTW Model) to promote digital health literacy, The research procedures were divided into 3 stages as follows:

1) **Stage 1:** Analyzing the CCBL via IoTW Model was a qualitative research method by a literature review. Therefore, this stage also was collected and analyzed qualitative data on the type of content analysis of research articles in ERIC, PubMed, Scopus, and Web of Science online databases. The research instruments used were 1) research quality evaluation forms, 2) data record forms, and 3) data analysis forms.

2) **Stage 2:** Synthesizing and validating the CCBL via IoTW Model based on the literature review. The research instruments used were 1) diagram and details of the CCBL via IoTW Model (draft version) and 2) content validation form built on a four-point Likert scale for the Content Validity Index (CVI) [47]. Accordingly, This stage consists of three sub-steps were as follows: 1) Synthesizing the diagram and details of the CCBL via IoTW Model (draft version), 2) Validating the synthesized the CCBL via IoTW Model by five experts who hold doctoral degrees or equivalent, work as instructor or researcher, and have at least three years' relevant experience, and 3) Calculating the average of all I-CVIs found that the S-CVI was at an acceptable level (S-CVI/Ave ≥ 0.90) [47]. Nevertheless, we have revised the diagram and details of the CCBL via IoTW Model as the experts' additional suggested to complete the model.

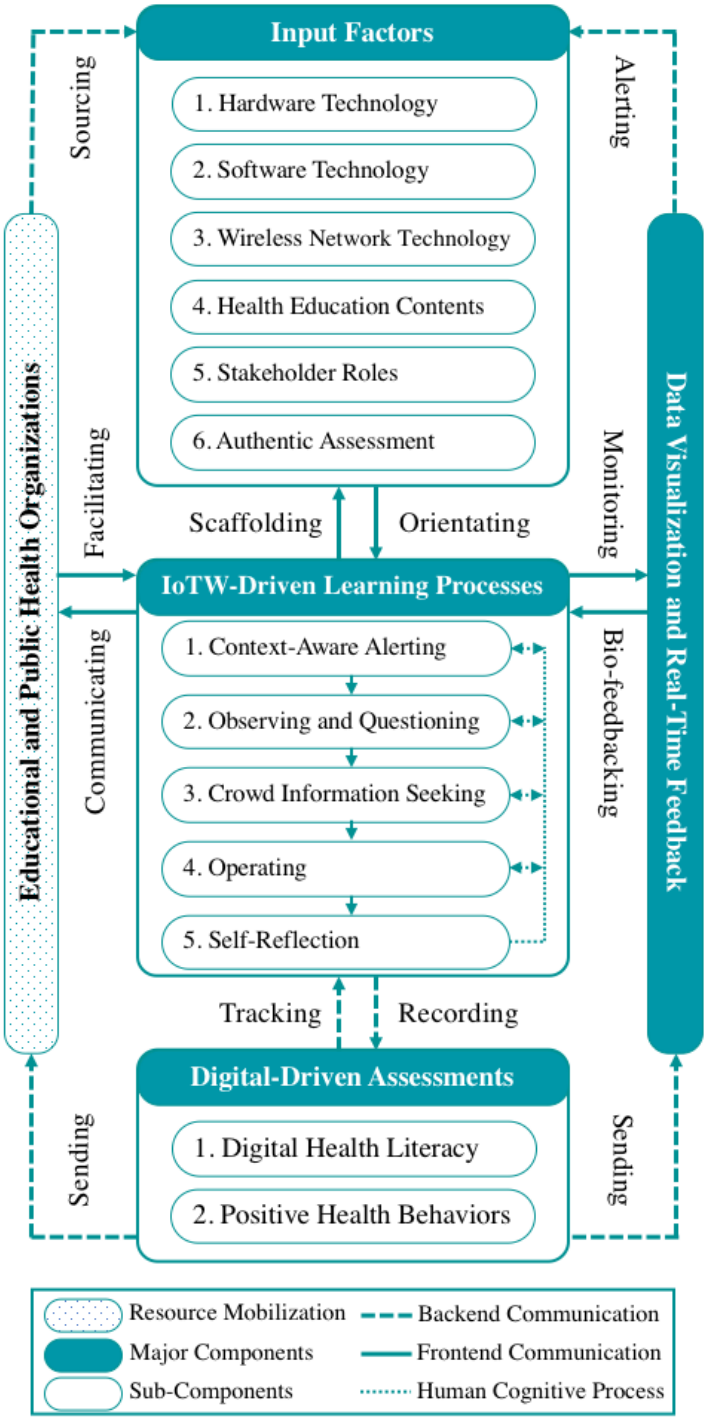
3) **Stage 3:** Evaluating the suitability of the CCBL via IoTW Model was a quantitative research method from an expert judgment using purposive sampling. The research instruments used were: 1) diagram and details of the CCBL via IoTW Model (revised version) and 2) suitability evaluation tool of the proposed CCBL via IoTW Model built on a five-point Likert scale; very high, high, moderate, low, and very low. Consequently, this stage has collected and analyzed quantitative data from 12 experts who hold doctoral degrees or equivalent, work as instructors or researchers, and have at least three years' relevant experience. These experts would consist of four experts in instructional science, four experts in educational technology, and four experts in educational measurement, who would consider and evaluate the suitability.

Results

The Proposed Model

The proposed the Model of Crowd Context-Based Learning via IoT Wearable Technology (CCBL via IoTW Model) to promote digital health literacy as shown in Figure 1.

Figure 1 The CCBL via IoTW Model to promote digital health literacy



From Figure 1, the CCBL via IoTW Model to promote digital health literacy has 4 major components:

1) **Input Factors**; this first major component is primary resources that the educational and public health organizations need to operate through resource mobilization to sourcing input factors consists of 6 sub-components: 1. Hardware technology (e.g., smart mobile device, smart wearable device, intelligent IoT device), 2. Software technology as a cognitive tool (e.g., digital health notification tools, digital health communication tools, digital health searching tools, digital health monitoring tools), 3. Wireless network technology (e.g., 2G, 3G, 4G, EDGE, 5G), 4. Health education contents (e.g., healthcare contents, disease prevention contents, health promotion contents) 5. Stakeholder roles (e.g., health

education instructors, professional health experts, learners), and 6. Authentic assessment (e.g., diagnostic-, formative-, summative assessment).

2) **IoTW-Driven Learning Processes**; this second major component is primary processes with dynamic, self-directed, and collaborative learning processes through issues based on real-life situations with crowdsourcing platforms via IoTW devices under a ubiquitous ecosystem consisting of processes: 1. Context-aware alerting is the first step that each learner will receive health information via the health notification tool in Graphical User Interface (GUI) to activate attention in the learners' cognitive process, 2. Observing and questioning is the step that each learner will respond to health content issues via the digital health communication tools in GUI to activate perception in the learners' cognitive process, 3. Crowd information seeking is the step that each learner will be seeking needed health information via the digital health searching tools in GUI to activate comprehension in the learners' cognitive process, 4. Operating is the step that each learner will health information applying for health care, disease prevention, health promotion via the digital health monitoring tools in GUI to activate decision making in the learners' cognitive process, and 5. Self-Reflection is the central step that each learner will review and reflect on their status, needs, and health behaviors via the digital health monitoring tools in GUI to activate meta-cognition in the learners' cognitive process.

3) **Digital-Driven Assessments (DDA)**; this third major component is the authentic assessment to foster interactions with physical objects that measure specific physiological and biological biometrics (e.g., fingerprint recognition, facial recognition, temperature, number of steps, blood pressure, heart rate, electrocardiogram, respiration) via digital technology in ubiquitous environments. DDA focuses on measuring the learning outcome variables based on components and indicators for assessing learners' performance consist of 2 sub-components: 1. Digital health literacy and 2. Positive health behaviors.

4) **Data Visualization and Real-Time Feedback**; this last major component is a dynamic process that consists of 3 sub-components: 1. Data receiving, 2. Data processing, and 3. Data transmitting. It starting from data receiving and processing from microcontrollers of DDA and real-time biofeedback data transmitting to IoTW-driven learning processes in GUI to activate human' cognitive process. In addition, Data visualization will be alerted on the data visualization concerning the numbers of delivery, visibility, discovery, and activity in IoTW-Driven learning processes.

The Suitability Study

Table 1. Results of evaluating the suitability of the CCBL via IoTW Model to promote digital health literacy

Evaluation Items	Suitability		
	Mean	**S.D.**	**Level**
1. Input factors			
1.1 Hardware technology	4.92	0.28	Very high

1.2 Software technology	4.67	0.47	Very high
1.3 Wireless network technology	4.83	0.37	Very high
1.4 Health education contents	4.67	0.47	Very high
1.5 Stakeholder roles	4.58	0.64	Very high
1.6 Authentic assessment	4.67	0.62	Very high
2. IoTW-driven learning processes			
2.1 Context-aware alerting	4.92	0.28	Very high
2.2 Observing and questioning	4.67	0.62	Very high
2.3 Crowd information seeking	4.75	0.43	Very high
2.4 Operating	4.58	0.64	Very high
2.5 Self-Reflection	4.92	0.28	Very high
3. Digital-driven assessments			
3.1 Digital health literacy	5.00	0.00	Very high
3.2 Positive health behaviors	4.92	0.28	Very high
4. Data visualization and real-time feedback			
4.1 Data receiving	4.67	0.62	Very high
4.2 Data processing	4.75	0.43	Very high
4.3 Data transmitting	4.83	0.37	Very high
5. Data communications			
5.1 Frontend communication	4.67	0.47	Very high
5.2 Backend communication	4.67	0.47	Very high
Overall average	**4.76**	**0.43**	Very high

From Table 1, presents the results of the suitability of the CCBL via IoTW Model to promote digital health literacy by expert judgment from 12 experts found the overall suitability rating of the proposed model at a very high level (Mean= 4.76, S.D. = 0.43), When considering each item, all items have suitability at a very high level. Experts agreed on the suitability of the proposed model that can be applied to designing digital interventions to promote digital health literacy.

Conclusion and Discussion

The COVID-19 pandemic has become a new challenge to find a sustainable solution across all sectors, including public-private partnerships (PPPs) of educational and public health organizations to facilitate citizens' Digital Health Literacy [3], [5]–[6]. DHL is a necessary learning outcome to access, apprehend, appraise, and apply digital health information from digital communication technologies in both dimensions of health promotion, health care, and disease prevention for citizens in the digital era. Nevertheless, the impact of COVID-19 is an opportunity for educational and public health organizations to learn from the

resource mobilization for sourcing, orientating, facilitating the IoT-Driven Learning Processes to promote digital health literacy [4]–[5], [10]–[13].

We proposed the CCBL via IoTW Model to promote digital health literacy towards achieving the SDGs in Goal 3 to promote healthy lives and promote well-being, and Goal 4 to enhance inclusive and equitable quality education and promote lifelong learning for all.

The CCBL via IoTW Model to promote digital health literacy consists of 4 major components: 1) Input factors, 2) IoTW-driven learning processes, 3) Digital-driven assessments, and 4) Data visualization and real-time feedback. The highlight of the CCBL via IoTW Model is the novel concept of resource mobilization by educational and public health organizations to sourcing the input factors also orientating and facilitating the IoTW-driven learning processes; by utilization of activities, cognitive tools, and graphical user interfaces in 5 steps are context-aware alerting, observing and questioning, crowd information seeking, operating, and self-reflection to stimulate learners' cognitive processes, including attention, perception, comprehension, decision-making, and meta-cognition. Furthermore, each step of the IoTW-driven learning process will be a stakeholder alerted on the data visualization concerning the numbers of delivery, visibility, discovery, and activity in IoTW-Driven learning processes. Moreover, the results of the suitability of the CCBL via the IoTW Model by expert judgment from 12 experts found the overall suitability rating of the proposed model at a very high level.

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