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Research Article

A blended learning model with IoT-based technology: effectively used when the COVID-19 pandemic?

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Abstract

IoT-based technology was considered to refer to all heterogeneous objects and devices through any networks, and Blended Learning (BL) is the educational approach to combine face-to-face (F2F) instruction with ICT instruction. In this COVID-19 pandemic, a model of BL with IoT-based maybe the best New Normal solution for all educational stakeholders. While Traditional F2F is forced to change by social distancing to prevent COVID-19. Many IoT-based "things" could be added in class to create and improve a smart learning environment while portable devices could be joined for the learning goals. This study divided BL into 4 characteristics; F2F, Self-paced, Tele-D, and Ubiquitous, which were further categorized into 3 typical cases of learning environments, Digital, Embedded, and Side-by-side cases. Content analysis method was used to analyze and synthesize a model from related literatures, textbooks, research, articles and websites. A framework of this model has 2 roles of user interfaces (teacher and student) which link 6 modules and a set of databases and 2 types of contexts (classroom and personal).

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Introduction

In this decade, the use of the internet has become a necessity in almost every aspect of ordinary life. Especially in this COVID-19 situation while the physical contact between human is banned to prevent virus spreading. All traditional way is forced to change into the new norms. Likewise, the daily life behaviors will be changed and driven by online technology that is called the New Normal. The Internet of Things (IoT) is a network of a wide range of everyday objects that can generate, exchange, and use information with minimum human participation. These devices vary in their size, computation power, energy capacity, and storage capability. IoT is the new paradigm term for all heterogeneous objects and devices connected through the world's networks, where "Thing" is an object of the physical world or the information world and is capable of being identified and integrated into the communication network. This concept is used like a very big umbrella for covering various aspects through the internet network, in which digital and physical entities can be linked and communicated (Siddiqui et al. 2019; Martino et al. 2018; Dong et al. 2017; Li et al. 2015; ITU-T, 2012; Miorandi et al. 2012). IoT integrates highly heterogeneous technologies and continuously supports new IoT-based applications in different domains, including pacemakers, blood pressure monitors, TVs, refrigerators, CCTVs, traffic lights, vehicles, and drones. All relative technologies foster and integrate IoT devices, including Big Data, Cloud Computing, 5G cellular, and AI technologies (Celesti et al. 2019; Lee, 2019; Terroso-Saenz et al. 2019; Savjani, 2019; Miorandi et al. 2012). So, almost everything: every location, device, sensor, software, etc., will be connected to each other. Both the real-world and the cyber-world will be seamlessly connected.

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IoT has many features to be considered: 1) Sensors, the basic essence of IoT's advantage. There are 3 types of sensors, according to the measurement characteristics, consisting of Physical, Chemical, and Biological sensors, which are able to detect and measure almost anything (position, presence, proximity, motion, velocity, displacement, temperature, humidity, moisture, acoustics, sound, vibration, chemical, gas, flow, force, load, torque, strain, pressure, leaks, levels, electricity, acceleration, tilt, machine vision, optical ambient light, magnetic fields, chemical contaminations in the environment, blood sugar levels, etc.); 2) Connectivity, proper connection to any platform, either server or cloud. This needs high-speed communication which is reliable, secure, and bi-directional. There are several networks for IoT, such as WSN, NB-IoT, Mobile, etc. These networks may be connected to the internet, or just to communicate with local in-groups; 3) Active engagement, IoT's advantage, which allows connected technology, products, or services to actively engage with each other. IoT can change the old way of passive interaction by bringing in active content, product, or service engagement; 4) Devices used in IoT are varied and diverse, with many brands, standards, proposes, or possibilities in the global world. They will be smaller but powerful and accurate, and 5) Artificial Intelligence (AI), computing systems which automatically operate with proper decisions by themselves, aiming to make things smarter to enhance all things around us and helping us achieve a better life. Now, there are many varied and complicated factors in IoT architecture, because the concept combines all different aspects to be able to connect. Many protocols, services, and technologies are provided to support IoT concepts, such as NFC, LoRaWAN, Cellular, WiFi, Zigbee, Z-Wave, and Bluetooth. (Martino et al. 2018; Savjani, 2019; Triantafyllou et al. 2018)

In the educational technology field, all stakeholders need to watch out for newly developed technologies constantly, especially concerning IoT, which blurs the line between online and offline. This presents new opportunities and challenges to integrate innovative IoT into normal learning systems. Blended Learning (BL) is an educational concept which is able to combine any technologies into the traditional classroom. The term "Blended" does not belong to a specific theory (Norberg et al. 2011); BL can blend any approaches or pedagogies, including constructivism, behaviorism, and cognitivist. Many educators refer to BL to combine new digital modalities into traditional or face-to-face (F2F) instruction (Graham, 2006; Graham et al. 2003). The Distance Education report 2008, by ICS Institute of Education Sciences, explained that a Hybrid/Blended online course is a new instruction for students, who can reduce their seated time in classrooms by learning online instead (Lewis & Parsad, 2008). Garrison and Vaughan (2011) said BL courses were required to fuse together a range of F2F and online learning to meet quality challenges and serve disciplinary goals effectively and efficiently. BL was differently defined by respective technologies in that time; web-based, distance learning, e-learning, and pervasive process technology (Suo & Shi, 2008; Driscoll, 2010; 2002; 1999). The latest of these, Norberg (2017; 2011), considered BL to be an ongoing long-term integration of ICT into the normality of education practice.

There are many problems with traditional learning held at a main learning place which BL tries to solve using new technologies, including weak scalability and lack of fidelity (Ratto et al. 2013; Suo et al. 2009; Shi et al. 2003; Johanson et al. 2002; Abowd, 1999). Suo and Shi (2008) shared the new idea of Smart Space technology that keeps the classroom as the main learning place and uses e-learning and new functions to foster learning experiences. Students can remotely join the class and report their feedback when they are not seated in the classroom. Moreover, Smart Space can capture all instructions during class for review and evaluation after class by both teacher and students. There are many terms and concepts related to BL in various degrees, including Hybrid, Smart classroom, Smart space, Smart learning environment, Ubiquitous/ Pervasive computing, Online learning, E-learning, Distance learning, Learning Management System, Flipped classroom, etc. (Norberg et al. 2017; Cockrum, 2017; Altamimi & Ramadan, 2016; Norberg et al. 2015; Moskal et al. 2013). BL has become a promising approach to create new learning environments in order to improve learning effectiveness and enrich learning experience. Such a smart learning environment may be able to support a wide range of teaching and learning activities in different subject matters at different levels. Nowadays, ubiquitous/pervasive computing or learning removes the limitation of time and space/place through the new cyber/digital world (Shi et al. 2003). So, now BL should not be categorized into only 2 parts, Online and Offline, or F2F and mediated instructors. This study will re-categorize it and show a BL model combining the strength of teacher-led and student self-paced learning together and show a framework for using this BL model with IoT-based technology.

Problem of Research

With the COVID-19 pandemic, whole global education being impacted and accelerated to change. The traditional learning needs to change into the New Normal discipline of the educational management. In Thailand, Online

Learning is used as the immediately solution whereas BL is one proper solution for balancing of all stakeholders in long term. Therefore, this study the questions is as follows:

- What are the general characteristics of BL by the matrix of place and time perspective?
- The sub questions are What will be the possible features of IoT-based for each category of BL?
- What's a framework of BL with IoT-based?

Method

Research Design

This study uses a qualitative content analysis method, which is a thematic analysis concentrating on the relationship between content and context that consists of organizing, classifying, comparing and extracting theoretical conclusions from papers and books (Cohen, Manion, & Morrison, 2007, Cresswell, 2008)

Population and Sample

Participants of this research are the relevant literature which are related to education and technology from four well-known online research database sources (IEEExplore, ScienceDirect, Scopus, and Springer), using the query keywords of IoT's features and functions. Then the author analyzed abstracts and contexts with the possible IoT's features that relate each category of BL with inclusion and exclusion criteria as the Table 1. The last search was conducted on 30 March 2020. This procedure yielded 85 papers that were categorized into two thematic areas; a) BL with IoT-based by places perspective, and b) BL with IoT-based by time perspective.

Table 1.

Inclusion and Exclusion Criteria

Inclusion criteria	Exclusion criteria
a) Published between 2000-2020 and available in full-text.	a) Emphasized application or hardware or network or very specific design in IoT technology
b) Was the empirical research that related IoT's feature.	b) Studies that mentioned "IoT" but were about IoT in industrial or supply chain
c) Purposed to detect personal or place's context by IoT's sensors.	
d) Represented the duplicate or alike features of IoT.	

Data Collection

The general characteristic of BL was divided into four groups by the matrix of place and time perspective as Figure 1. The author determined whether participants met the criteria include of a) focus on IoT-based technology, b) focus on probable features for "anytime", c) focus on probable features for "anywhere", d) identify "place" thematic areas and divide into in-class and out-class context, and e) identify "time" thematic areas into live-stream with instructor and peers (Synchronous) and self-paced (Asynchronous) context.

Results

What are the general characteristics of BL by the matrix of place and time perspective?

Several definitions of BL were analyzed; the author defined BL as an educational approach to combine F2F instruction with ICT, which was synthesized from several of these definitions. Meanwhile, IoT-based technology was defined as heterogeneous objects and devices used through any world's networks, in which digital and physical entities can be linked and communicated. First, this result shows the main characteristics of BL, which were categorized by time and place into 4 characteristics, as per Figure 1.

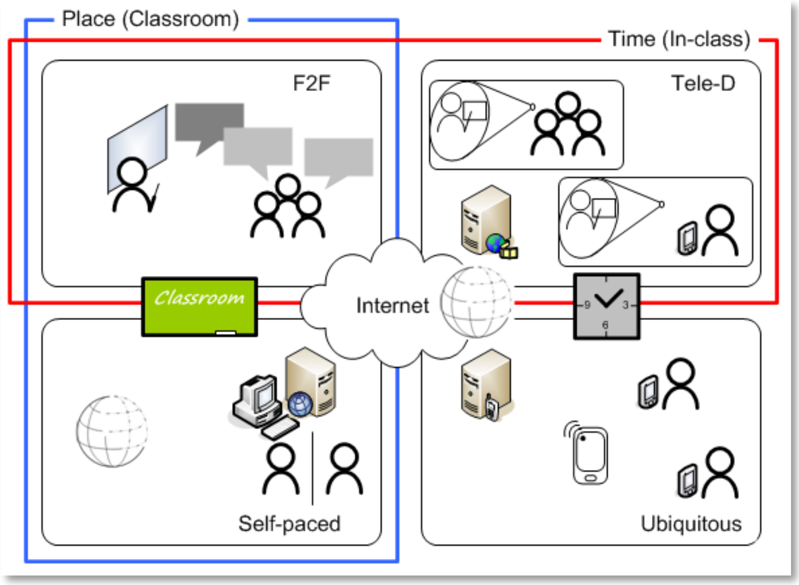

Figure 1.
Four Characteristics of BL (Applied from Norberg 2017).

What will be the possible features of IoT-based for each category of BL?
First, this author considers the place perspective, which means all students must attend a classroom (Place). There are 2 characteristics (F2F and Self-paced).

- F2F is face to face between teacher and students in a classroom, which is traditional instruction. This characteristic focuses on teacher-led learning to teach large groups of students, which is a synchronous learning process, allowing several interactions to happen, including teaching, peer work, discussions, etc. The main features are F2F strategies, focus on interactions, collaboration, and communication in the classroom.
- Self-paced is an individual learning process for each student, who can learn by themselves from some instruction materials or facilitators in the classroom. This characteristic focuses on adaptive instructions or computer-based solutions which allow students to learn to follow their own pace. It implies that all students in the same classroom use some adaptive solutions together, and each of them is able to learn by themselves, while being motivated by media interactive materials such as CAI, CBI, WBI, AR, Context-aware, etc. The main features are that adaptive instruction occurs in-classroom and the teacher acts as a coach or adviser.

In the next 2 characteristics, a classroom in the real-world is not necessary. Students can learn in the cyber-world through the data communication network and devices.

- Tele-D is a teacher-led experience which students can access by live-streaming in the cyber-world. It needs data communication technology to cross real-world distance obstacles. This characteristic focuses on virtual F2F instructions which foster interactive responses from students to connect with the teacher and peers in the classroom by their texts, sounds, tasks, etc. The main features of Tele-D are communication devices, Tele-education, and Distance learning support.
- Ubiquitous is a U-learning concept in which each student can learn by themselves anytime, anywhere, including Online, Mobile, Context-aware, and Web-based learning. Some MOOCs and Flipped classroom concepts are involved, but this characteristic focuses on suitable times and places, apart from the classroom experience, in which students are able to learn in the cyber-world. The main features of Ubiquitous are the online instructions and materials, which students can access anytime through digital devices.

There are 2 types of context in these 4 characteristics: 1) the classroom context (e.g., sound, temperature, light, humidity, air flow, etc.), which are detected by embedded IoT-based digital devices, and 2) the personal context of each student (e.g., movement, response, concentration, etc.), which are detected by IoT-based digital devices or smart wearable devices. The apportionment of these contexts to the 4 characteristics are presented in Figure 2.

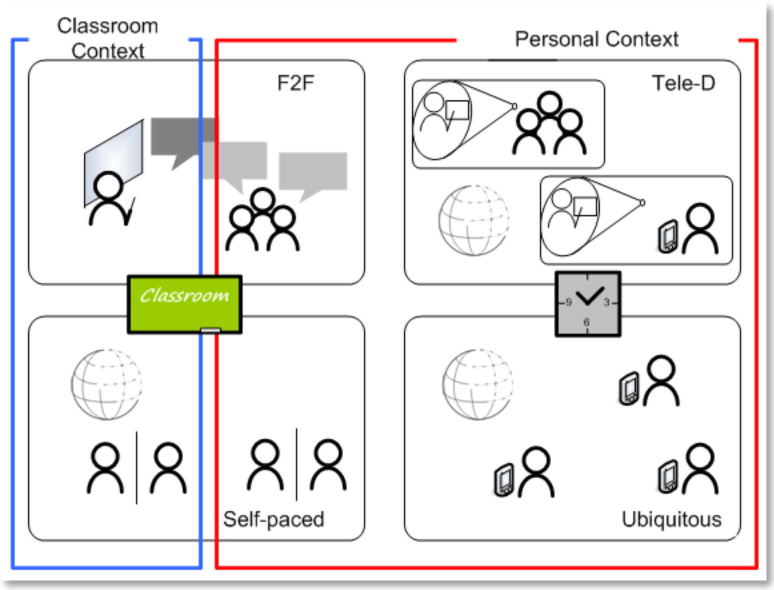

Figure 2.
Apportionment of Contexts in the BL Model

In this study, the combination of IoT-based digital devices implied smartphones, tablets, smart blackboards, wearable devices, smart devices, and software that supports learning management and processes. Typically, IoT-based technology comprises heterogeneous objects and devices which have sensors to measure some aspects of the physical environment or wearers and which send this digital information through networks or the internet. BL with IoT-based model has the relationship of digital devices with learning environment into 3 typical cases (Koper, 2014).

A) The digital case, in which digital devices provide only digital stimulated data without non-digital stimuli. 1) In F2F, the teacher can use digital presentation devices to provide digital information to stimulate a whole class of students, such as visualizers, digital cameras, document cameras, smart blackboards, interactive projectors, digital podiums, or LCD/LED big screens. 2) In Self-paced, the teacher can let students learn with an adaptive instruction by themselves, such as CAI, CBI, or WBI, with guidance. Brusilovsky & Peylo (2003) provided the Adaptive and Intelligent Web-based (AIWEB) format, with the "Just put it on the web" concept for blending into the F2F traditional classroom. 3) In Tele-D, the teacher can upload digital materials, such as e-books, lesson clips, task assignments, or video records, for students to access by smart devices, laptops, or personal computers. 4) In Ubiquitous, students can access all online digital materials by portable smart devices anywhere. Many researchers have blended this solution with the Flipped Classroom concept, such as Thai et al. (2017), who found that students in the Flipped Classroom setting had the highest learning performance and a positive effect on self-efficacy beliefs and intrinsic motivation, but not on perceived flexibility. Brumitt et al. (2002) designed and developed the EasyLiving project, which integrated all diverse I/O devices for the intelligent environment. This system included middleware, world location-based context, world perception, and all support services in a single command center and user interface.

B) The embedded case, which provides stimulated data from both the real-world physical environment and the relative digital-world augment to enrich the student's cognitive representation. 1) In F2F, Embedded sensors can be added in the classroom to measure some aspects of the physical environment, including physical, chemical, and biological sensors, which impact the student's performance, learning processes, and/or health, such as light, heat, temperature, air flow, sound, etc. Uzelac et al. (2015) used low-cost smart devices to analyze the impact of some physical parameters in a classroom on the students' focus, where the term "focus" referred to the students' subjective feeling of their ability to concentrate on a lecture at a given moment. The results showed there are 3 significant measured parameters for determining students' focus; the level of CO_2, the average value of the absolute deviations received from noise, and the combination of temperature and humidity (humidex). Jeon et al. (2018) and Jin et al. (2016) proposed IoT-based occupancy detection systems, with an extraction algorithm and proxy (SbP) as a sensing paradigm to detect occupancy in an indoor environment. Haverinen-Shaughnessy et al. (2015) reported that Indoor Environment Quality in a classroom impacted the students' performance and health. They found health outcomes were associated with both ventilation rate and culturable bacteria. The students' performance was associated with both indoor temperature and ventilation rate. In conclusion, classroom ventilation rate, temperature, and hygiene of high contact surfaces appear to be important IEQ parameters, potentially related to student health and/or performance. 2) In Self-paced, classroom environment was controlled to foster and facilitate students to focus on their pace. Shih et al. (2005) developed a system which allowed students to read SCORM-Compliant course materials on hardcopy papers while an OCR-like pen was used as an interaction mechanism, called the Hard SCORM. Therefore, students could read textbooks in a traditional manner, while the behavior of reading was incorporated with the SCORM specification. 3) In Tele-D, Embedded sensors were added in a classroom to stream digital signals such as sound, vision, and motion to the cyber-world or was recorded to evaluate and improve on later. Abowd (1999) used the Smart Space concept of IBM to design Classroom 2000, which is able to capture the lecture experience and broadcast it live or record it. Suo et al. (2008) stated how, in the cyberspace world of IoT, students can use several Pervasive computing devices to discuss in the same classroom in the real-world or connect multiple classrooms together. 4) In Ubiquitous, Augmented Reality and/or Context-aware solutions can foster anywhere learning in the real-world with relative digital information. Perera et al. (2013) surveyed and provided an in-depth analysis of context life cycles, then evaluated a subset of 50 projects which represented the majority of research and commercial solutions proposed in the field of context-aware computing conducted over the last decade. Finally, they highlighted the lessons to be learnt from the past and some possible directions for future research in Context-aware. Probst et al. (2019) reported the integration of IoT and AR technology in mechanical engineering in Austrian technical education. They descripted the IoT platform Thingworx for an educational perspective, as well as the training aspects from the platform developers' perspective. Additionally, they presented some diploma thesis with AR and IoT supplements.

C) The side-by-side case, which adds digital devices as learning function supporters, such as information contents, practices, testing and feedback, etc. 1) In F2F, the teacher can use Personal Response Systems, Clickers, or some mobile applications to support learning functions of F2F strategies. Ratto et al. (2003) developed ActiveClass, a simple client-server application for enhancing participation in a classroom setting via small mobile wireless devices; then, students could anonymously ask questions, answer polls, and give the professor feedback on the class. Every student and the professor saw these lists of questions, poll results, etc. Garrison & Vaughan (2011), Akyol & Garrison (2008), and Garrison et al. (2000) provided computer-mediated communication (CMC) and computer conferencing for supporting the community of inquiry (COI) experience to support Social, Cognitive, and Teaching presence cores. They suggested that computer conferencing and the integration of F2F and online activities have considerable potential to create a COI for educational purposes, especially in higher education experiences. 2) In Self-paced, the teacher can use an embedded IoT object for AR and/or Context-aware learning with some environment settings in the classroom. Chiu et al. (2016) blended context awareness with the U-learning concept called b-learning. They designed the B-MONS mechanism to guide and navigate students to learn efficiently in the Taiwan National Museum environment. They compared the efficiency of b-learning with other learning platforms, and the results indicated that the b-learning group performed better than the u-learning and e-learning groups. Hara & Kuwabara (2015) reported on an Interstage AR processing server (Interstage AR), which uses AR technology to overlay digital information obtained via ICT display on a smart device and has a variety of features that foster innovation in on-site work. It can improve the accuracy and quality of fieldwork by operations on screens displaying actual facilities, enables users to input messages passed on to others and facilitates preventive maintenance while in the field. 3) In Tele-D, students can use smart devices, such as smartphones, tablets, and laptops, to access live classroom signals. Xie et al. (2001) set up a tele-education classroom with wall-size media-boards and some devices to support a teacher's activities, including observing both in-class and distance students, handwriting on a media-board, and gesturing to conduct the class activities. While the other media-board shows the description and information of distant students, the teacher can manage classroom activities and distance students like a traditional classroom. Chen & Looi (2007) blended online discussion in class. They found that in-class, online discussion can provide a wider spectrum of discussion perspectives, equalize participation in discussion, and promote cognitive thinking skills and in-depth information processing. However, the lack of F2F interactions and the need for sufficient time to write online postings pose challenges in implementing online discussion for F2F classroom learning. Al-Sharhan (2016) introduced a comprehensive model of smart classrooms as a part of a Technology Enhanced Learning (TEL) environment, which systemically integrated the tools of ICT with teaching-learning practices, as well as school management. Teacher/instructor readiness in the TEL environment or head office, using IP telephony and video conferencing to provide the technique needed to extend the communication services and replace the F2F with online meetings, without having to leave the workspace, was investigated. Ramadhani et al. (2019) reported the results of the Digital-based learning with the model of FPBLM on LMS-Google Classroom for second-level high school students. This flipped-classroom model provided a new experience in mathematics both in-class and outside. Saputro & Tri (2019) reported the effectiveness and benefits of scientific-based Learning Management System (LMS) on the In-network Learning System (SPADA) were easy to conduct, practical, test, discussion, assign, and effective on the results of the pedagogical material summative learning of the Madrasa PPG teachers at the IAIN Salatiga, Indonesia. 4) In Ubiquitous, students can use smart devices to access online courses and give responses to feedback or tasks. Utts et al. (2003) studied a Hybrid course with internet-based instruction and compared traditional and hybrid courses, in which the hybrid course meant the class met only once a week, but with students using web-based materials and textbooks instead. They found the performance of students in the hybrid class equaled the traditional class, but students in the hybrid class were slightly less positive in their subjective evaluation of the course.

Abraham (2016) developed a Thinworx IoT-based platform with an application on an Android phone to integrate IoT-based activities at Seattle University as part of efforts to leverage IoT technology in education; this could potentially enhance recruitment and retention efforts.

What's a framework of BL with IoT-based?

For a framework of this model to implement in a classroom environment, this study considered adapting the SLE framework (Hwang, 2014), which included 1) a learning status detecting module, 2) a learning performance evaluation module, 3) an adaptive learning task module, 4) an adaptive learning content module, 5) a personal learning support module, 6) a set of necessary databases to collect and keep the learner's profiles and portfolios, the learning materials, test bank, tools, and knowledge base, these databases having relationships to all previous modules, and 7) an inference engine for determining the value of tasks, strategies, and tools to be possibly combined. This result is shown in Figure 3.

So, in this framework, the user interface has a minimum of 2 roles of user (teacher and students), and it consists of 6 modules and a set of databases: 1) a learning status detecting module, which detects both classroom context (e.g., sound and temperature) and personal context (e.g., motion and location) from the IoT-based digital devices. These context data will be collected in the portfolios database, and the status will be reported by the user interface; 2) a learning performance evaluation module, which collects and evaluates all students' performance from tests, practice, or by observation. This module is able to use test items from the test bank database to evaluate performance based on portfolios data; 3) an adaptive learning task module, which assigns adaptive learning tasks to each student based on their learning performance and status. This module can use the learner sheets and materials database to consider an adaptive task for each student; 4) an adaptive learning content module, which provides the adaptive learning materials to each student based on their need. This module can use the learning tools database; 5) a personal learning support module, which provides learning support to foster each student based on their learning needs. It can use the learners' profiles, and 6) an inference engine, which has a knowledge base to process and consider the value of candidate learning tasks, tools, or strategies, as well as their possible combinations.

COVID-19 was having strong impact on our traditional society and economy, not even the traditional educations. Only Learn from home by the Online or Distance learning without teacher-student interaction enough that is not good for the long term although students become more digitally minded. The combination of BL with IoT-based model is the best suitable for all stakeholders include of faculty, educators, teachers, administrators, staffs, and students to maintain all interactions and relationships. Singh et al. (2020) explored the IoT implementation effectively used for COVID-19 patients that IoT helps to reduce cost and improve outcome by reviewing all relative papers. They found twelve significant applications of IoT which have ultimately forced the researchers, academicians, and scientists to propose some productive solutions to overcome or confront this pandemic. Likewise, this BL with IoT-based model should be suitable to use against this global pandemic too.

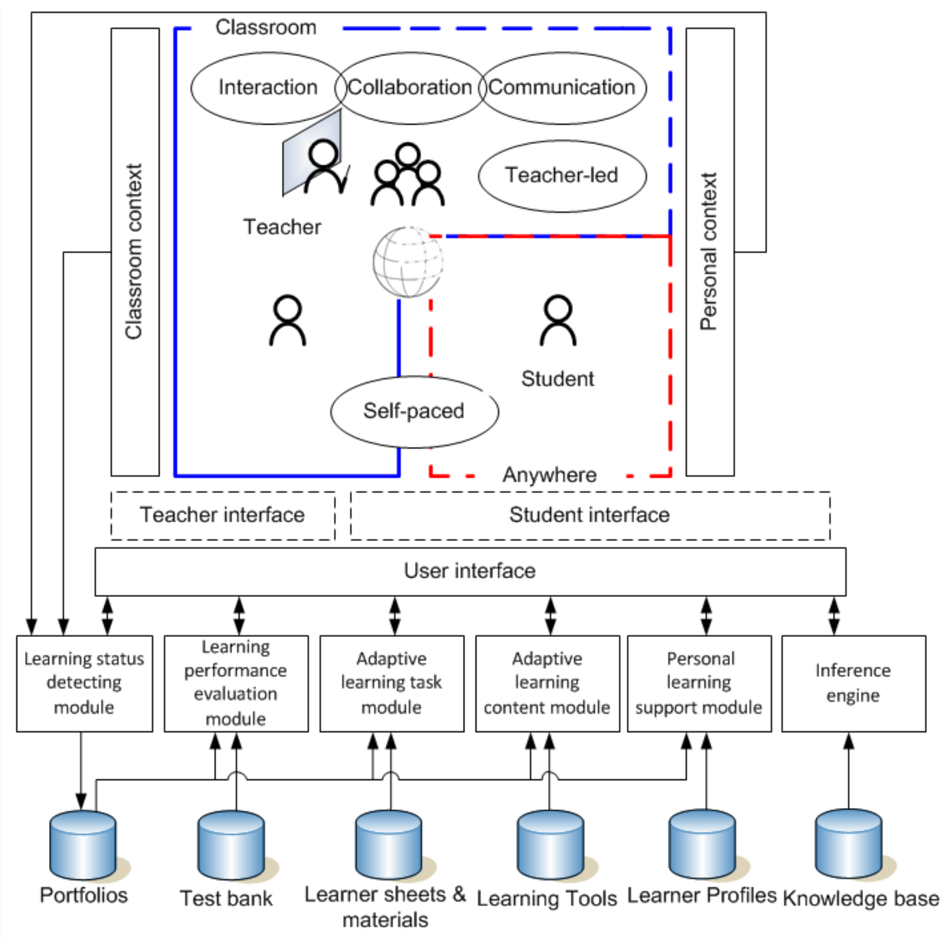

Figure 3.
The Framework of a BL Model with IoT-based Technology (Adapted from Hwang 2014)

Discussion and Conclusion

Typically, IoT-based technology comprises heterogeneous objects and devices which have sensors to measure some aspects about the physical environment or wearers and send this digital information through networks or the internet. In this study, "digital devices" represents the combination of some IoT-based devices, including smartphones, tablets, smart blackboards, wearable devices, and software which supports learning management and processes. Meanwhile, BL is the educational approach to combine F2F instruction with ICT. So, the results show there are 4 characteristics of the model (F2F, Self-paced, Tele-D, and Ubiquitous) which relate to 3 typical cases (digital, embedded, and side-by-side case).

In the BL model with IoT-based framework, there are 2 contexts: 1) a classroom context with important parameters that can be detected by IoT devices. All data will be collected and processed to report the classroom's status, from which teachers or administrators can control and manage the classroom context for fostering and facilitating learning in the classroom, whether by teacher-led (large group) or self-paced (individual) approaches, and. 2) a personal context with personal parameters that can be detected by personal devices or wearable devices which are able to be identified, in order to collect and process personal data to report and track the students' status and learning processes. These reports will be used to choose the adaptive tasks, contents, materials, and learning tools by the other modules. Both classroom and personal contexts will be collected into the portfolios database by a learning status detecting module. While some IoT-based devices can be used to support the teacher-led approach in F2F and Tele-D characteristics for interactions, collaboration, and communication in a classroom, other individual IoT-based devices can be used to support the adaptive learning of a self-paced approach in the Self-paced and Ubiquitous characteristics. New IoT innovations arise frequently; this empirical study shows possible ideas which are categorized, and a framework of this model to implement, depending on a faculty's status.

Some issues need to be discussed. First, because of the diversity and variation in range of IoTs, security and privacy issues are of concern. Many researchers have tried to find solutions for security and privacy, such as Siddiqui et al.

(2019), Casola et al. (2019), Wang et al. (2019), Fernández-Caramés & Fraga-Lamas (2018), Pan et al. (2018), Minoli & Occhiogrosso (2018), Liang & Chen (2018), Tsunoda & Keeni (2016), Dorri et al. (2016), and McNall & Stanton (2011). There are many new platforms, new blockchain systems, and new approaches which are still being discussed as solutions. For the BL model with IoT-based technology, the author is interested in a solution from Celesti et al. (2019), who studied a new healthcare service called Tele-Rehabilitation (TRaaS) using IoT wearable devices. They prevented this issue using pseudo-anonymized information, where whoever accesses personal data is unable to know the healthcare status of a patient or the identity of a related patient. Indeed, they kept personal data in a local and private storage system, with data able to be pushed onto external commercial cloud providers. So, the faculty can process students' data without any risk for the student's privacy using this pseudo-anonymized information method. Second, a classic issue of innovation is adoption concern. Sivathanu (2017) reported this issue in IoT-based wearable devices for the healthcare of older adults at India, who were 60-65 years old and had a traditional habit of visiting doctors for medical health checkups. They found it difficult to use wearable devices, and also perceived the risk that their healthcare data could be accessed by anyone through the internet. On the other hand, in China, people of all ages have adopted IoT-based technology, include corporations. Dong et al. (2017) studied the usage of IoT-based technology in China, and the results showed a smart home consumers' perceived ease of use, privacy risk, and usefulness of IoT-based technology. In this model, it is not a serious issue, because youthful students usually adopt innovations as long as they are useful. Al-Hitmi & Sherif (2018) explored the fairness perception of Petroleum employees in Qatar of IoT-enabled monitoring. They found this monitoring invasion does not negatively influence employee perceptions of fairness, because it is a culture that is driven by productivity and strongly adheres to policies and standards and has a highly competitive job market with lucrative rewards.

Finally, when IoT-based technology increases, the internet of various types of networks will have connections at various levels, including resource consumption and high data density, as per Aftab et al. (2019), Altamimi & Ramadan (2016), and Koucheryavy et al. (2016). They concluded that IoT technology requires the development of new services, data transfer modes, and new traffic arrangements for efficiency and quality of solutions. On the other hand, Terroso-Saenz et al. (2019) stated the need for effective development of IoT applications under realistic conditions and has generated various ecosystems of methodologies and integrated IoT platforms. Today, COVID-19 disrupting many traditional norms in every fields while IoT-based technology will be accelerated to adopt. Global IoT-based in healthcare will be the first prior for tracking patient's vital information without directly physician-patient interaction. Now, many smart cities begin use IoT-based application to check-in/out all crowded places for the public health investigation when COVID-19 patient was found such as Thaichana platform of Thailand. Likewise, in the educational filed, the author hopes this BL with IoT-based could be implemented to be the global vanguard of New Normal in the further.

Recommendations

BL with IoT-based is the new model to use IoTs as the educational technology for BL concept. The result of query of text "BL and IoT" was not found. Only the smart classroom or smart environment concepts are the nearly related with IoT whereas they did not cover for all BL. Therefore, this study categorized BL groups by time and place before analyzed and synthesized IoT's features which related and abled to comply and implement with BL instead.

This study defined the overall of BL with IoT-based as the new normal of educational technology. Therefore, the specific academic levels were not focused. The apportionments of BL with IoT for blending are different based on academic levels, courses, and etc. This study's framework is an initial framework to be a guideline for future studying proper proportion in the specific academic level or course.

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