Journal of Education and Learning (EduLearn)
Vol. 20, No. 1, February 2026, pp. 510~522
ISSN: 2089-9823 DOI: 10.11591/edulearn.v20i1.22726

Bandwidth-immediacy-social connectedness framework for rural secondary school's extended m-learning experience

Ain Arissa Zainuddin[1], Noris Mohd Norowi[1], Rahmita Wirza O. K. Rahmat[1], Mas Nida Md. Khambari[2]
[1]Department of Multimedia, Faculty of Computer Science and Information Technology, Universiti Putra Malaysia, Serdang, Malaysia
[2]Department of Foundations of Education, Faculty of Educational Studies, Universiti Putra Malaysia, Serdang, Malaysia

Article Info

Article history:

Received Jul 10, 2024
Revised Feb 12, 2025
Accepted Mar 19, 2025

Keywords:

Bandwidth
Framework
Immediacy
M-learning
Secondary school
Social connectedness

ABSTRACT

Mobility, instant access to knowledge, social interaction, and flexibility in terms of time, location, and pace are just few of the many benefits that mobile learning (m-learning) provides. To build an ideal m-learning platform, a framework acts as a plan that directs the construction of a unified, user-friendly, and efficient m-learning environment. Through the utilisation of Stanford's bandwidth-immediacy matrix as a foundational framework, the purpose of this study is to investigate the possibility of incorporating social connectedness as z-axis in between the bandwidth and immediacy axes by proposing a 3-dimensional matrix called bandwidth-immediacy-social connectedness in blue zone framework, shorten as BISC-B framework. A progressive web application (PWA) called bridging the urban-rural knowledge dissemination and learning gap (BURDLe) was developed with the implementation of BISC-B in order to fulfil the objectives of this study. BURDLe was evaluated for 2 weeks by students and teachers from Bachok, Kelantan, a remote Malaysian district. This study collected data sequentially using explanatory methods. Quantitative and descriptive analysis were used to summarise questionnaire data. Conversely, interviews were qualitatively analysed to validate the questionnaire results. The result of this study has revealed that social-connectedness is a factor that can influence the m-learning experience, along with bandwidth utilisation and immediacy.

Corresponding Author:

Noris Mohd Norowi
Department of Multimedia, Faculty of Computer Science and Information Technology
Universiti Putra Malaysia
43400, Serdang, Selangor, Malaysia
Email: noris@upm.edu.my

1. INTRODUCTION

Mobile learning (m-learning), provides several benefits such as the ability to learn on the go, quick access to information, connectivity, social engagement, and flexibility in terms of time, location, speed, and pace [1], [2]. The presence of these characteristics makes it possible for educational activities to be carried out in a synchronous or asynchronous manner, inside networked systems or even in isolated contexts. In every instance when the definition of m-learning was discussed, the focus was typically placed on the technologies or gadgets themselves, instead of on the educational challenges that appear to be problematic [3]. This is because even in the absence of students physically seated at a desktop computer, the process of digital learning can still occur through the use of m-learning [4]. This indicates that technology has advanced to the point where students may utilise it to acquire information through the internet, which serves as a vast library of knowledge, hence improving the quality of education [5].

However, this shift does not significantly impact individuals residing in far inland areas. Students residing in rural locations have limited access to technological advancements, particularly in terms of exposure to m-learning, which is being rapidly implemented in urban areas. Students residing in rural areas may have financial limitations when it comes to acquiring electronic devices, which might result in their having low proficiency in digital skills [6]. It is imperative to give significant consideration to this issue, as schools in rural areas generally receive less attention than their urban counterparts [7]. Continued persistence of this situation will result in students residing in rural areas falling more behind in the rapidly advancing digital age.

Frameworks are essential for applications as they provide a structured framework for attaining their objectives. A graphical representation is used to illustrate the expected link between the causes and consequences in a specific situation in which it is typically created before the actual study begins. Previous studies indicate limited research on the relationship between bandwidth, immediacy, and social connectivity due to their narrow focus. Back in the 2000s, information saturation, guidance in knowledge acquisition, and the promotion of collaborative learning were priorities [8].

Subsequently, m-learning began to attract attention and further investigations were conducted in several aspects of m-learning, including efficiency, socio-cultural factors, and the learning experience. Several m-learning frameworks are generic, as they were not designed for specific educational settings [9]–[12]. Overly complex or simplistic content may cause discontent or disinterest among learners, as cognitive, emotional, and social development differs across education levels [13]. Despite a concentration on a specific level of education, most researched frameworks target higher-level students with more advanced cognitive ability than secondary school students.

It is abundantly clear that m-learning relies on an internet connection to operate well, resulting in the consumption of bandwidth. The ability of a communication channel to facilitate the transmission of data is referred to as its bandwidth. Immediacy in human-computer interaction refers to designing systems that provide rapid and intuitive responses, enhancing user satisfaction and efficiency [14], [15] while in education, immediacy refers to communication that reduces perceived psychological distance between individuals [16], [17].

Using various media might affect the level of immediacy experienced by teachers and students, depending on bandwidth needs. The bandwidth-immediacy matrix in Figure 1 was developed by Stanford in 2020 with the objective to compare these 2 factors on a coordinate plane. Despite the fact that it is straightforward to engage in a discussion over a video conversation in order to recreate the classroom atmosphere in an online setting, there are 2 variables that contradict this assumption-bandwidth and immediacy [18]. A high utilisation of bandwidth in an m-learning environment makes it difficult for students who do not have availability to high internet access to engage in the course. The vertical axis of the matrix places bandwidth, and the horizontal axis places immediacy. This matrix divides educational technologies into four zones.

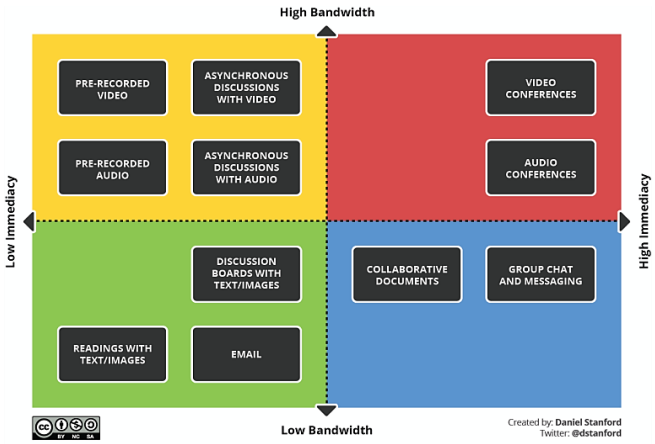

Figure 1. Bandwidth-immediacy matrix

This study aims to suggest that by using Stanford's bandwidth-immediacy matrix as a base of framework, another aspect can be exist as z-axis in between the bandwidth and immediacy axes, see in Figure 2. In a regular classroom context, social connectivity is a natural occurrence that exists. It is also an attribute that should be brought in in an m-learning setting. To foster social connectivity in a virtual educational setting, teachers must establish a positive and interactive approach to engage with students. This will help students feel connected and engaged in the m-learning space [19].

Engaging in online learning using social media platforms such as Facebook can enhance students' social connections with both their peers and educators as social media platforms are specifically built to facilitate genial interactions and the establishment of a sociable environment can greatly enhance social interaction [20], [21]. Although the utilisation of technological platforms in online education continues to grow, the lack of social connectivity could hinder the efficiency of m-learning as it could impact one's ability to concentrate and dedicate oneself to academic tasks [22]. More importantly, heightened anxiety has had a negative impact on students' self-assurance and readiness in which can leading to delays in academic tasks [23], [24].

With the intention of future research specifically targeting students and teachers residing in remote areas, an optimal approach for developing a framework is to build it upon the blue zone in Stanford's bandwidth-immediacy matrix. This will guarantee that the expenses associated with bandwidth usage are minimised while still reaching a high level of responsiveness. Hence, a 3-dimensional matrix called bandwidth-immediacy-social connectedness in blue zone framework (BISC-B). Framework in Figure 3, has been developed with the aim of enhancing Stanford's bandwidth-immediacy matrix framework. This enhanced framework can be incorporated into m-learning applications to enhance the m-learning experience for secondary school students residing in areas with limited bandwidth. The BISC-B system is positioned on the left axis of social connection due to the fact that chat group messaging, as a kind of digital media, offers a lesser level of social connectivity as compared to videoconferencing or audioconferencing [25]. The proposed framework suggests that even with low-bandwidth mediums that offer quick responses, such as group chat messaging and collaborative document tools, it is possible to create a sense of social connection among users when the tool or app environment is appropriately configured.

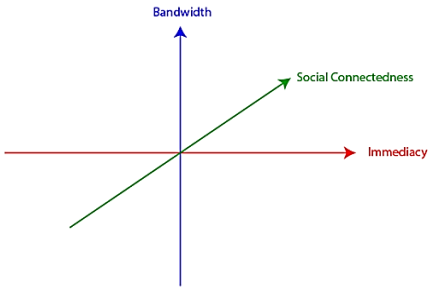

Figure 2. Social connectedness factor lies in between the bandwidth and immediacy axes

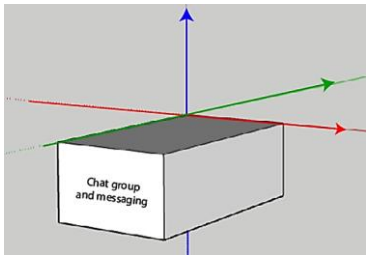

Figure 3. Proposed BISC-B framework

2. METHOD

2.1. BURDLe development

In order to fulfil the objectives of this study, a progressive web application (PWA) called bridging the urban-rural knowledge dissemination and learning gap (BURDLe) was developed. The aspects described in BISC-B, namely bandwidth, immediacy, and social connectivity, have been incorporated into this PWA. To reduce mobile data usage, BURDLe employed a text-based interface as it reduces the utilisation of video and animation in the system.

Chatbot is necessary to address student inquiries when teachers are unavailable. Artificial intelligence (AI) and machine learning (ML) chatbots were not implemented due to insufficient knowledge in these disciplines. A simple chatbot based on database and query keyword matching will be used instead. The chat tool in BURDLe enable real-time communication between individuals and groups. Notes, exercises, attendance, and questions (teachers' module) have their own distinct functions and convenient access points.

The design of the BURDLe aim to foster social connectedness among users, reducing feelings of loneliness and maintaining motivation among students and teachers during the m-learning process. Overall, BURDLe was developed with strong inspiration from the WhatsApp application. It is designed to be real-time and minimise mobile data usage by primarily focusing on text-based conversations. However, BURDLe goes beyond WhatsApp by catering specifically to the education environment, offering features such as notes, exercise, and attendance as shown in Figure 4.

Figure 4. Screenshot of students' chatting space with notes, exercise, and attendance features

2.2. Participant's recruitment

This study recruiting participants from Sekolah Menengah Kebangsaan Sri Gunung, which is located in Bachok, Kelantan. This is because, based on interviews conducted with participants from this school during the preliminary investigation, it was determined that they reside in an area with inadequate internet connectivity [26]. As a result, they rely on WhatsApp instead of using Google Meet. This indicates that rural Malaysian students may encounter additional challenges when conducting their studies using video conferencing [27]. The most suitable candidates to evaluate BURDLe and its suggested BISC-B are the secondary school students and teachers from this particular region. The 3 teachers with over a decade of teaching expertise participated in this research. A group of 34 students, ranging in age from 13 to 16 years old, were successfully recruited.

2.3. Data collection

During the evaluation of the PWA, the participants were evaluated in their rural areas. First, a briefing on the BURDLe was provided to the individuals who were being involved and later is evaluated by each participant over the course of 2 weeks. Participants must install BURDLe's PWA in Firefox before participating in user testing. After successfully installing BURDLe in the browser, a shortcut will appear on the home screen. For the 2-week BURDLe testing period, users were advised to refrain from using the browser for other purposes. This prevents BURDLe's mobile data usage from getting mixed with other activities. This study relies on BURDLe, a browser-reliant PWA, as it cannot independently assess data usage as a mobile app.

To test the BURDLe, participants should utilise only mobile data, as the smartphone system cannot determine data usage by an application using Wi-Fi. To monitor mobile data usage, participants were instructed to adjust their smartphone settings. Participants must navigate to settings→connections→data usage→billing cycle and data warning→start date for billing cycle. Participants must select the function with the same meaning for each smartphone, which may have a unique name. The billing cycle must begin on the first day of BURDLe testing. If testing is scheduled on the 25th of the month, the date must be set accordingly. This ensures Mozilla Firefox begins counting BURDLe's mobile data use from that date.

Explanatory sequential approach was employed throughout this phase. Immediately following 2 weeks of evaluation, questionnaires were distributed for completion. The questionnaire utilised a mix of Likert scale and empty spaces. Participants had a week to fill out the Google Form questionnaire after evaluating the BURDLe PWA.

Once the data collected from the questionnaire were evaluated, interviews were performed to explore the underlying significance of the acquired results. The 2 teacher participants expressed their willingness to attend the interview sessions. One person joined the interview remotely through a video call utilising Google Meet, while another teacher participant was unable to attend due to time restrictions caused by her schoolwork. Consequently, she provided a recorded voice response to the interview questions. On the other hand, a total of 9 students engaged in 3 video call sessions using WhatsApp's video call feature. The first group consists of 3 students, the second group consists of 4 students, and the third group consists of 2 students. The use of different platforms was based on the teachers' familiarity with Google Meet and the students' familiarity with WhatsApp video call.

2.4. Data analysis

Given that this part of the study employed an explanatory sequential approach for data collection, the data obtained from the questionnaire was quantitatively evaluated and subsequently summarised using a descriptive analysis approach. Once the participants completed the questionnaire and submitted it, the gathered data was entered into SPSS software to compute statistics such as the frequency, mean, and standard deviation for each question. As the required statistics had been obtained, a descriptive analysis was conducted to comprehend the data's pattern.

Conversely, interviews were subjected to qualitative analysis in order to obtain data that can corroborate the findings obtained from the questionnaire. In regards to interview videos, they were initially transcribed, translated, annotated, and analysed to identify the underlying themes of the content. Subsequently, the collected data were correlated with the findings obtained from the questionnaire in order to identify any connections or associations between them.

3. RESULTS AND DISCUSSION

Following the collection of the required statistics, descriptive analysis was carried out in order to gain an understanding of the pattern of the data.

3.1. Bandwidth

According to the findings in Table 1, a teacher who took part in the study found that BURDLe used less than 50 MB of data throughout a period of one to 2 weeks. The remaining 2 participants were uncertain about the utilisation of the data as they were unable to ascertain the details. Certain teacher participants exceed a data usage of 50 MB due to their engagement in activities such as downloading or uploading multiple files to BURDLe or utilizing the BURDLe-specific browser for other purposes. During the testing of BURDLe, it is possible that certain teachers, as participants, inadvertently utilised Wi-Fi, hence hindering the smartphone system's ability to accurately determine the amount of mobile data consumed.

On the other hand, over 50% of them said that BURDLe consumes less than 50 MB of their mobile data during one to 2 weeks of usage. A mere 11.76% of users report that BURDLe consumes over 50 MB of mobile data. Approximately 20.59% of the student participants are uncertain about the amount of mobile data consumed by the BURDLe. Certain student participants may have exceeded 50 MB of mobile data usage due to their extensive uploading or downloading of data on BURDLe, or their utilisation of the BURDLe-specific browser for other activities. During BURDLe testing, certain student participants may have inadvertently established a connection to Wi-Fi, thereby impeding the smartphone system's ability to calculate the quantity of mobile data utilised.

Table 1. Statistics on teacher participants' mobile data used during BURDLe testing

Attributes	Category	Frequency (teacher)	Percent of cases (%) (teacher)	Frequency (student)	Percent of cases (%) (student)
Mobile data used after 2 weeks of use	≤50 MB	1	33.33	23	67.65
	>50 MB	0	0.00	4	11.76
	Unsure	2	66.67	7	20.59

3.2. Immediacy

From the teachers' perspective, Table 2 shows the lowest mean score (μ=3.3333) and dispersion value (σ=0.5774). The fact that many students submitted their exercises via BURDLe over the deadline did not bother them. The highest mean score in this area is shared by Q3, Q6, and Q12, with equal mean and standard deviation values of μ=4.3333 and σ=0.5774. All participating teachers agree that BURDLe assistant improved their ability to assist students after working hours by respecting their privacy. They also agree that attendance and exercise submission data enable parents to track their students' engagement quickly. Additionally, Q1, Q2, and

Q11 shared the second-highest mean score of μ=4.0000. According to a dispersion value of σ=0.0000, teachers believe the BURDLe assistant function in the app is vital for providing timely responses to students when the teacher is unavailable. Teachers could instantaneously monitor student engagement with a dispersion value of σ=1.0000 using the online student name list during class.

The students' lowest score (μ=4.0588 and σ=0.77621) for Q2 indicates that an auto reply in BURDLe still improves teacher-student communication. When their teacher is unavailable, hearing a response from someone else reduces anxiety, even if it was not their teacher. The mean score value (μ=4.2353) is shared by Q7, Q10, and Q13. They agree that teacher-uploaded notes are easily accessible due to their separation from other chat group members, with a dispersion value of σ=0.69887. Second, they acknowledge the ease of access to teacher-uploaded notes. In the second case, a distribution value of σ=0.69887, separating exercises, notes, and attendance checking allows for easier differentiation between uploaded teacher materials, reducing confusion and time spent finding appropriate materials. In the third scenario, BURDLe's Attendance function allows students to swiftly punch in within the time range given by teachers, with a dispersion value of σ=0.69887. This reduces scrolling in services like WhatsApp and Telegram, where students must copy the latest attendance. The highest mean score (μ=4.2647) and dispersion value (σ=0.7096) were obtained using Q8. Similar to notes and attendance, exercise functions are distinct from conversation, requiring students to find appropriate materials.

Table 2. Question codes, perceptions, and statistics covered regarding immediacy from participants

Question code	Question	Mean (teacher)	Std. dev. (teacher)	Mean (student)	Std. dev. (student)
Q1	I feel BURDLe assistant in the app is important.	4.0000	0.0000	4.1176	0.8077
Q2	BURDLe assistant helps my students to get instant replies while I am offline.	4.0000	0.0000	-	-
	BURDLe assistant helped me and my classmates get an immediate response while the teacher was offline.	-	-	4.0588	0.7762
Q3	BURDLe assistant really helped me to answer student questions during outside office hours.	4.3333	0.5774	-	-
Q4	I received many student exercises submissions before the set deadline.	3.6667	0.5774	-	-
Q5	I receive a lot of exercise submissions from students even after the set deadline.	3.3333	0.5774	-	-
Q6	Exercise submissions review reports make it easier for me to track student participation more efficiently.	4.3333	0.5774	-	-
Q7	Through the notes function, BURDLe helps me to access teacher-uploaded notes faster.	-	-	4.2353	0.6989
Q8	Through the exercise function, BURDLe helps me to access teacher uploaded exercises more quickly.	-	-	4.2647	0.7096
Q9	I feel BURDLe makes it easier for me to submit assignments faster.	-	-	4.1176	0.7693
Q10	Isolating notes and exercises through the notes and exercise functions helped me be less confused with the material uploaded by the teacher.	-	-	4.2353	0.6989
Q11	The list of names of students who are online helps me to track their participation more quickly during the class.	4.0000	1.0000	-	-
Q12	Attendance reports make it easier for me to track student participation more quickly.	4.3333	0.5774	-	-
Q13	Through the attendance function, BURDLe helps me to mark attendance more quickly.	-	-	4.2353	0.8187
Q14	The class period created by the teacher prompted me to mark attendance.	-	-	4.2059	0.8083

3.3. Social connectedness

Q23 and Q25 have the lowest mean score (μ=4.0000, σ=0.0000) in Table 3 from teachers' perspective. The teacher participants suggested using the BURDLe assistant to address student inquiries while they were away to reduce feelings of isolation. They admit to like chatting with students in the chat group. Teachers report feeling comfortable engaging in chats with students via the BURDLe chat group, with the highest mean scores (μ=4.6667, σ=0.5774) in social connectedness (Q18). Additionally, Q21, where teachers agree they feel closer to students when communicating directly, had the same mean score and dispersion value. The second highest mean score in social connectedness was achieved by Q15, Q16, Q17, and Q22, with the same distribution values (μ=4.3333, σ=0.5774). Teacher participants report feeling more connected to their students due to the chat group atmosphere in BURDLe. Teacher participants agree that chat groups foster closer student connections compared to formal learning tools. The teachers in the survey also agree with this sentiment. Participating teachers reported reduced loneliness as BURDLe displayed the names of online as well as offline students.

Q16 had the lowest mean score (μ=3.5588, σ=0.7464) from students' perspective. Students feel more connected to peers when a chat group is provided, compared with other m-learning platforms without this feature. Since BURDLe displays students' names in the conversation space when they submit teacher-assigned activities using the exercise function, students are motivated to submit their own. The mean score of μ=4.1417 and σ=0.7836 is the highest in this area. Q18 and Q21 share a mean score of μ=3.9412. Students report feeling comfortable asking and answering questions of their teacher in the chat group, with a dispersion value of σ=0.7762. Dispersion number σ=0.8507 indicates that students feel more emotionally connected to peers when they can directly message them.

Interviews were done to further investigate the results obtained from the questionnaire. Several candidates were chosen to participate in the interview session following the completion of the questionnaire. Out of the total number of professors, 2 out of 3 volunteered to participate in the interview. Similarly, out of the total number of students, 10 out of 34 chose to participate. The teachers were interviewed individually, whereas the students were interviewed in a focus group. Following the occurrence of transcription and translation, several key themes emerged from the interview.

Table 3. Question codes, perceptions, and statistics covered regarding immediacy from participants

Question code	Question	Mean (teacher)	Std. dev. (teacher)	Mean (student)	Std. dev. (student)
Q15	I feel the environment of the chat group makes me closer to the students.	4.3333	0.5774	-	-
Q16	I feel chat groups make students closer to each other compared to other formal learning applications.	4.3333	0.5774	-	-
	I feel the chat group atmosphere brings me closer to my classmates compared to other formal learning apps.	-	-	3.5588	0.7464
Q17	I feel less lonely when looking at the list of names of online students.	4.3333	0.5774		
	I feel less lonely when looking at the list of names of online classmates.	-	-	4.0882	0.9960
Q18	I feel comfortable to have discussions with students via chat groups.	4.6667	0.5774		
	I feel comfortable to ask questions and respond to teachers via chat groups.	-	-	3.9412	0.7762
Q19	I feel comfortable chatting or asking classmates about learning subjects in the group chat space.	-	-	3.8529	0.7440
Q20	I feel comfortable talking to classmates about learning subjects via direct messaging.			3.8235	0.8864
Q21	I feel closer to students every time I can message them directly.	4.6667	0.5774	-	-
	I feel closer to my classmates every time I can message them directly.			3.9412	0.8507
Q22	I feel closer to students compared to other formal learning applications with the chatting space.	4.3333	0.5774	-	-
	I feel closer to my classmates compared to other formal learning applications with the existence of group chat space.	-	-	3.9706	0.7582
Q23	When the BURDLe assistant replied to the student's question whenever I was offline, I felt the student's conversation did not hang.	4.0000	0.0000	-	-
	When the BURDLe assistant answered my questions and friends while the teacher was offline, I felt the conversation did not left out.	-	-	4.0294	0.8699
Q24	I am motivated to expedite the submission of exercises when a classmate's name appears in the chat group after he or she submits the exercises.	-	-	4.1417	0.7836
Q25	I enjoy being able to interact with students in the chat group.	4.0000	0.0000	-	-
	I enjoy being able to interact with teachers and friends neutrally via chat group.	-	-	4.1176	0.7693

3.4. A lightweight app is very important for m-learning

The majority of teachers and students who took part in the BURDLe testing encountered no difficulties in accessing or using the PWA whenever there was an internet connection. This was due to the fact that the text-based programme consumed less data, resulting in a lightweight web app. This implementation is a lightweight approach that guarantees the delivery of content while minimising any negative impact on the device's performance [28], [29]. This is in line with the idea that the usage of text-based m-learning services for delivering material is mainly motivated by its cost-effectiveness, ease of access, and wide coverage over mobile networks [30].

"*When I use BURDLe, it is easy to load. It is maybe because the app is light and my Internet connection is good. Plus, even though my Internet connection is good, sometimes there are some apps that whenever I try to load it, it takes a long time to finish the load.*" (Teacher 1)
"*Whenever I try to load BURDLe, I face no problem so far.*" (Student 3)

3.5. Human response is preferred over automatic answer, even if it costs delay

Automated responses were implemented to address student inquiries when teachers are offline. This approach applies when students post their questions with the @cikgu tag in the chat group. The BURDLe assistant will activate if the teacher has activated it, else there would be no autoreply. Teachers construct questions to anticipate future student questions, then provide answers and keywords for students to use. If the requested keywords are missing, the BURDLe assistant will instruct students to wait for the teacher's response.

Following the evaluation of BURDLe, it was found that both teachers and students preferred human responses to BURDLe assistant, despite knowing that the wait times were longer. When it comes to dealing with unexpected questions and topics that deviate from predetermined frames, humans are exceptional [31]–[33]. The human species is more comfortable waiting than receiving a response that is devoid of context. Because BURDLe assistant was developed utilising a precise matching method, rather than ML or AI, to match keywords with database responses, it is possible that participants felt this way [34].

"*Students still have to wait for me to reply as I only keyed in a few keywords, so the answer given by BURDLe assistant might not meet the student questions' context. So, I think my students would prefer for me to reply because whenever they ask about something, they would like to get detailed answers as they will rain me with questions after a question has been answered.*" (Teacher 1)
"*I think that we get the reply in time, but I do prefer to get the reply from the teacher because sometimes BURDLe assistant does not really answer the questions asked so far.*" (Student 2)

One of the good outcomes of enabling BURDLe assistant is that it has helped students feel less anxious about obtaining a response from the instructor. This is true even if the response that is provided by BURDLe assistant does not correspond to the context of the questions that they originally posed. It is possible for the chatbot's responses to give users the impression that they are being observed and to lessen the sense that they are being ignored [35], [36].

"*We get the reply in no time from BURDLe assistant whenever we ask the questions during teacher absence, so I feel like I do not have to wait anymore.*" (Student 1)

3.6. Feelings of achievement and appreciation

A built-in exercise function is included in the BURDLe platform, which gives teachers the ability to upload assignments in the group chat for their students to work on. Once the assignments have been completed, the students are expected to submit them through the platform. If a student were to submit their work through BURDLe, their name would be displayed in the chat group. This would serve to inform all of the members of the group that the student had recently handed in the assignment. Because of this, the other student is unwittingly motivated to finish their project as quickly as possible and turn it in through BURDLe.

This arises as a result of the fact that the other students grow agitated whenever they see the name of their peers shown in the group chat, which indicates that the former student has completed the assignment. When individuals see the achievements of their peers, it has the potential to inspire and push them to strive for like levels of success [37], [38]. It is possible that this tendency is the result of a desire to gain the satisfaction that comes with the completion of tasks and the achievement of goals that have been established by teachers [39].

"*I feel like I was challenged whenever I knew my classmates submitted the homework.*" (Student 1)
"*I am afraid that I might be left behind when I see other friends have submitted the homework.*" (Student 2)
"*Whenever I see my classmate's name appear in the group notification for submitting the homework, I want my name to pop up too, so my friends know that I also submitted the homework.*" (Student 10)

3.7. The organisation of tasks is vital

Before adopting BURDLe, students submitted assignments using instant messaging group chats. Moreover, it was challenging due to the need to record attendance in a chained conversation as students entered their names individually. The list was tedious and sometimes names were lost due to faulty copying of the preceding list. With well-organized and marked BURDLe, participants reported faster searching and access to required materials. Notes and exercises uploaded to prior instant messaging apps were stored in the chat group

space and removed when a new chat arrived. Later users must scroll up to view uploaded notes and teacher/student exercises, which can be time-consuming.

Effective operations organisation eliminates repetitive processes and speeds up access to relevant content [40], [41]. Logical feature placement in interfaces builds user trust during navigation [42], [43]. Logical function organisation reduces cognitive load when searching for options. This practice reduces cognitive load and improves users' focus on tasks [44].

> "*I think* that *BURDLe is systematic because in WhatsApp, whenever students submit their work, they sometimes mix it up with pictures and I have to create a separate folder. Sometimes I have to create a Google Form and upload it myself because I do not want to mix exercise with notes or pictures. When I use BURDLe, I know that these things would not mix up so I can do my work faster and smoother.*" (Teacher 1)
> "*The* Exercise *function that is featured in BURDLe allows students to submit homework at the set time and when I want to do the marking, I do not have to look for the submitted homework in another place because I know that the file will be placed in a specific space.*" (Teacher 2)
> "*Materials are separated accordingly – notes in notes space, exercises will be in exercise space, and attendance will be in attendance space, so it is easier to use. It saves my time from scrolling up like in WhatsApp.*" (Student 3)
> "*I like the attendance feature the most because I do not have to scroll up and copy paste the attendance list like in WhatsApp.*" (Student 7)
> "*In BURDLe, I just have to punch in on time instead typing my name into the chained chat.*" (Student 8)

3.8. Application that include a daily social application look and feel promotes a neutral social atmosphere

A neutral social interaction or mood can be created when a new application that individuals are already familiar with and commonly use has the same visual design as popular social apps. Adhering to user expectations in design ensures that navigation is more intuitive, allowing users to easily find and exploit features that are similar to those present in other programmes [45], [46]. Despite the new app having a different purpose, individuals will still feel comfortable engaging with it indirectly. This app is a lightweight and user-friendly application that aims to integrate social networks in the contemporary post-era. It acts as a basic and easily adaptable learning tool [28].

> "*I feel more comfortable to chat in the group chat that is provided in BURDLe. The reason is that my students are familiar with WhatsApp, and BURDLe environment itself looks like WhatsApp. Chatting through the chat feature in Google Meet, students usually just listen when I talk, so they do not seem proactive in responding to chat.*" (Teacher 1)
> "*It is comfortable to ask through BURDLE since it looks like WhatsApp. It has become our habit to ask in a place like that.*" (Student 3)
> "*BURDLe is provide a comfortable environment for me to interact with my friends like in WhatsApp.*" (Student 10)

3.9. Recommendation

This study has several identifiable shortcomings. Regarding the BURDLe itself, it did not incorporate any ML or other forms of AI that might potentially enhance the accuracy of the autoreply. This omission indirectly hampers the ability of students to receive prompt and precise responses. In addition, the BURDLe PWA lacked the ability to display conversation or alert alerts on the phone's home screen, which had a negative impact on immediacy. Users must launch the application in order to ascertain the presence of any notifications.

Furthermore, BURDLe did not conduct a direct evaluation of its performance in relation to existing m-learning or social media technologies. In addition, the participants only evaluated BURDLe for a duration of 2 weeks. This limited timeframe may not have allowed for a comprehensive assessment of its whole impact on teaching and learning (T&L). Furthermore, it is possible that the short duration of the study could have influenced the amount of mobile data usage to some degree.

Considering the drawbacks outlined, it is possible to envision potential future studies aimed at enhancing the study. ML or any other form of AI can be integrated into a chatbot that responds to students' inquiries anytime the teacher activates it. This helps students to receive more precise answers promptly, eliminating the need to wait for the teacher's response.

In addition, BURDLe has the potential to be enhanced as a mobile application, allowing it to deliver chat messages or other notifications directly to the user's phone home screen, ensuring quick alertness. In addition, this study solely concentrates on validating the BISC-B theory, which emphasises low bandwidth,

high immediacy, and low social connectivity. However, further research might be undertaken to explore additional aspects within the conceptual framework. Moreover, this study exclusively examined the secondary school students residing in regions with limited internet connectivity. BURDLe indeed possesses the capacity to undergo testing across many levels of study, including primary school and higher education.

4. CONCLUSION

This study has several discoveries. Based on the data analysis of participants in the study, it was found that social-connectedness is an aspect that can impact the m-learning experience, in addition to bandwidth utilisation and immediacy. With Stanford bandwidth-immediacy matrix as a base, a 3-dimensional theory was developed. This theory places social connectivity (z-axis) between the components of bandwidth (x-axis) and immediacy (y-axis). The blue zone in Stanford's bandwidth-immediacy matrix is the optimal initial step for creating a new conceptual framework. This will maintain a low bandwidth cost while achieving a high level of immediacy. A novel conceptual framework, known as the BISC-B framework, has been developed. This framework aims to enhance the m-learning experience for high school students residing in low bandwidth regions. It is anticipated that this 3-dimensional matrix will be utilised in m-learning applications. Several features were identified and emphasised at the conclusion of the investigation, corroborating some findings from the quantitative data and outcomes following the BURDLe testing. These data were acquired through conducting interviews with the participants. Regarding bandwidth, lightweight applications for m-learning effectively facilitate access for teachers and students in places with limited bandwidth.

In terms of immediacy, real-time conversations enhance the T&L experience by eliminating the need to wait for responses from peers, students, or teachers, which is a limitation of other asynchronous m-learning systems such as Google Classroom. In addition, an automatic response, specifically the BURDLe assistant, will promptly reply to students' inquiries as soon as it is activated by teachers. Despite the fact that BURDLe assistant's responses occasionally fail to directly address the specific context of students' questions, this may lead students to believe that it is better to wait for their teacher's response. However, this can somewhat alleviate the anxiety that students experience while waiting for a reply from their teacher. Furthermore, the presence of well-structured features in the m-learning application is significant. It facilitates expedited access for teachers and students to pertinent resources, including notes, exercises, and attendance records, by eliminating the need for physical storage. Unlike WhatsApp and Telegram, BURDLe offers a function that surpasses them in terms of being a platform for T&L. This feature prevents the misuse and abuse of social media, which is not the original purpose of these platforms.

In the case of social connectedness, students experienced a sense of achievement and contentment while submitting their activities. Whenever a student submitted their project to BURDLe, their name would be displayed in the chat group, notifying everyone that they had already handed it in. Unintentionally, this inadvertently serves as a catalyst for the other student to also finish and turn in their assignment. This occurs because when other students observe their buddy's name being shown in the group chat area, indicating that their friend has already turned in the homework, they become restless. This demonstrates that the social connectivity aspect is corroborated in BURDLe. In general, this feature was absent on other m-learning platforms. Consequently, the experience of online or virtual learning for students has historically been solitary and isolated. Designing an application that closely resembles one that people are already familiar with and frequently use might create a neutral social environment. Despite the new app serving a different purpose, they will still feel at ease connecting with it.

ACKNOWLEDGEMENTS

The authors would like to thank the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA), the Ministry of Education Malaysia, and Universiti Putra Malaysia for their support. Special thanks are also extended to the teachers and students of SMK Katibas (Song, Sarawak), SMK Seri Gunong (Bachok, Kelantan), and SMK Dato Mustapha (Sekinchan, Selangor), as well as to all the parents and children who participated in this study.

FUNDING INFORMATION

This study was fully funded by the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) through the Seed Fund for Research and Training (SFRT), grant number 56810000. The grant, amounting to USD 12,000, supported the purchase of research equipment, honoraria for respondents, a 24-month salary for a graduate research assistant, as well as training and advisory support. The authors sincerely thank SEARCA for its generous contribution to this research.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Ain Arissa Zainuddin	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	
Noris Mohd Norowi	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Rahmita Wirza O. K. Rahmat	✓			✓						✓		✓		
Mas Nida Md. Khambari	✓			✓						✓		✓		

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known financial, personal, professional, or non-financial competing interests that could have influenced the work reported in this paper. Authors state no conflict of interest.

INFORMED CONSENT

Informed consent was obtained from all individuals who participated in this study. All minor participants were involved with the presence and consent of their respective guardians.

ETHICAL APPROVAL

The research involving human participants has complied with all relevant national regulations and institutional policies, in accordance with the principles of the Helsinki Declaration. It has been approved by the authors' institutional review board or equivalent committee. Ethical clearance was also granted by the Ethical Committee of Universiti Putra Malaysia (JKEUPM) and the Ministry of Education Malaysia under clearance number KPM.600-3/2/3-eras(8342).

DATA AVAILABILITY

The data supporting the findings of this study are available upon reasonable request. Interested parties can access the data by contacting the corresponding author, [NMN].

REFERENCES

[1] W. M. A. F. W. Hamzah, M. H. Yusoff, I. Ismail, and A. Yacob, "The behavioural intentions of secondary school students to use tablet as a mobile learning device," *International Journal of Interactive Mobile Technologies (iJIM)*, vol. 14, no. 13, pp. 161–171, Aug. 2020, doi: 10.3991/ijim.v14i13.13027.

[2] S. Y. Park, M.-W. Nam, and S.-B. Cha, "University students' behavioral intention to use mobile learning: evaluating the technology acceptance model," *British Journal of Educational Technology*, vol. 43, no. 4, 2011, doi: 10.1111/j.1467-8535.2011.01229.x.

[3] M. M. Grant, "Difficulties in defining mobile learning: analysis, design characteristics, and implications," *Educational Technology Research and Development*, vol. 67, no. 2, pp. 361–388, Jan. 2019, doi: 10.1007/s11423-018-09641-4.

[4] M. R. A. Samad, Z. H. Ihsan, and F. Khalid, "The use of mobile learning in teaching and learning session during the COVID-19 pandemic in Malaysia," *Journal of Contemporary Social Science and Education Studies (JOCSSES)*, vol. 1, no. 2, pp. 46–65, 2021, doi: 10.5281/zenodo.10329936.

[5] R. Rahamat, "Designing mobile learning: empirical journey to reality in Malaysian secondary school context," *EduLite: Journal of English Education, Literature and Culture*, vol. 4, no. 1, pp. 13–24, Feb. 2019, doi: 10.30659/e.4.1.13-24.

[6] M. J. Alam, K. Ogawa, and S. R. B. Islam, "E-learning as a doubled-edge sword for academic achievements of university students in developing countries: insights from Bangladesh," *Sustainability*, vol. 15, no. 9, p. 7282, Jan. 2023, doi: 10.3390/su15097282.

[7] A. Marwan, B. Sumintono, and N. Mislan, "Revitalizing rural schools: a challenge for Malaysia," *Educational Issues, Research and Policies*, vol. 1, no. 1, pp. 172–188, 2012.

[8] R. M. Bernard and B. R. D. Rubalcava, "Collaborative online distance learning: issues for future practice and research," *Distance Education*, vol. 21, no. 2, pp. 260-277, 2000, doi: 10.1080/0158791000210205.

[9] M. L. Koole, "A model for framing mobile learning," in *Mobile Learning : Transforming the Delivery of Education and Training*, M. Ally. Ed., Edmonton: Athabasca University Press, 2010, pp. 25-47.

[9] S. Moya and M. Camacho, "Developing a framework for mobile learning adoption and sustainable development," *Technology, Knowledge and Learning*, vol. 28, no. 2, pp. 727–744, Aug. 2021 doi: 10.1007/s10758-021-09537-y.

[10] N. Parsazadeh, R. Ali, and M. Rezaei, "A framework for cooperative and interactive mobile learning to improve online information evaluation skills," *Computers & Education*, vol. 120, pp. 75–89, May 2018, doi: 10.1016/j.compedu.2018.01.010.

[11] H. Crompton, "Moving toward a mobile learning landscape: presenting a mlearning integration framework," *Interactive Technology and Smart Education*, vol. 14, no. 2, pp. 97–109, Jun. 2017, doi: 10.1108/itse-02-2017-0018.

[12] G. Vavoula and M. Sharples, "Meeting the challenges in evaluating mobile learning," *International Journal of Mobile and Blended Learning*, vol. 1, no. 2, pp. 54–75, Apr. 2009, doi: 10.4018/jmbl.2009040104.

[13] J. Wang and M. Jou, "The influence of mobile-learning flipped classrooms on the emotional learning and cognitive flexibility of students of different levels of learning achievement," *Interactive Learning Environments*, vol. 31, no. 3, pp. 1309–1321, 2023, doi: 10.1080/10494820.2020.1830806.

[14] F. Hemmert and G. Joost, "Embodiment, immediacy and thinghood in the design of human-computer interaction," *Design and Complexity - DRS International Conference*, Jul. 2010, pp. 1–10.

[15] D. Ungar, H. Lieberman, and C. Fry, "Debugging and the experience of immediacy," *Communications of the ACM*, vol. 40, no. 4, pp. 38–43, Apr. 1997, doi: 10.1145/248448.248457.

[16] K. S. Thweatt and J. C. McCroskey, "Teacher nonimmediacy and misbehavior: unintentional negative communication," *Communication Research Reports*, vol. 13, no. 2, pp. 198–204, Sep. 1996, doi: 10.1080/08824099609362087.

[17] M. F. Fahara and A. L. Castro, "Teaching strategies to promote immediacy in online graduate courses," *Open Praxis*, vol. 7, no. 4, pp. 363–376, Nov. 2015, doi: 10.5944/openpraxis.7.4.228.

[18] M. Ramlatchan and G. S. Watson, "Enhancing instructor credibility and immediacy in the design of distance learning systems and virtual classroom environments," *The Journal of Applied Instructional Design*, vol. 9, no. 2, 2020, doi: 10.51869/92mrgsw.

[19] J. I. Vallade, R. Kaufmann, and T. K. Frey, "Facilitating students' motivation in the basic communication course: a self-determination theory perspective," *Basic Communication Course Annual*, vol. 32, no. 1, pp. 124–147, Jan. 2020.

[20] M. Akcaoglu and E. Lee, "Using Facebook groups to support social presence in online learning," *Distance Education*, vol. 39, no. 3, pp. 334–352, Jun. 2018, doi: 10.1080/01587919.2018.1476842.

[21] J. Weidlich and T. J. Bastiaens, "Explaining social presence and the quality of online learning with the SIPS model," *Computers in Human Behavior*, vol. 72, pp. 479–487, Jul. 2017, doi: 10.1016/j.chb.2017.03.016.

[22] J. L. Borelli, D. K. Bond, S. Fox, and M. Horn-Mallers, "Relational savoring reduces physiological reactivity and enhances psychological agency in older adults," J*ournal of Applied Gerontology*, vol. 39, no. 3, 2019, doi: 10.1177/0733464819866972.

[23] K. W. Choi, Y.-K. Kim, and H. J. Jeon, "Comorbid anxiety and depression: clinical and conceptual consideration and transdiagnostic treatment," Anxiety Disorders: Rethinking and Understanding Recent Discoveries, Y.-K. Kim, Ed., Singapore: Springer Singapore, 2020, pp. 219–235, doi: 10.1007/978-981-32-9705-0_14.

[24] W. Cao *et al.*, "The psychological impact of the COVID-19 epidemic on college students in China," *Psychiatry Research*, vol. 287, p. 112934, Mar. 2020, doi: 10.1016/j.psychres.2020.112934.

[25] M. H. Nguyen, J. Gruber, W. Marler, A. Hunsaker, J. Fuchs, and E. Hargittai, "Staying connected while physically apart: digital communication when face-to-face interactions are limited," *New Media & Society*, vol. 24, no. 9, pp. 2046–2067, Feb. 2021, doi: 10.1177/1461444820985442.

[26] N. M. Norowi *et al*., "Bridging the urban-rural divide on knowledge dissemination and learning process (BURDLe)," *International University Carnival on E-Learning (IUCEL) Proceedings*, 2022, pp. 593-598.

[27] T. R. Ming, N. M. Norowi, R. Wirza, and A. Kamaruddin, "Designing a collaborative virtual conference application: challenges, requirements and guidelines," *Future Internet*, vol. 13, no. 10, p. 253, Sep. 2021, doi: 10.3390/fi13100253.

[28] A. M. Khachan and A. Özmen, "IMSSAP: After-school interactive mobile learning student support application," C*omputer Applications in Engineering Education*, vol. 27, no. 3, pp. 543–552, Jan. 2019, doi: 10.1002/cae.22096.

[29] G. Karopoulos, G. Portokalidis, J. Domingo-Ferrer, Y.-D. Lin, D. Geneiatakis, and G. Kambourakis, "Security and privacy in unified communications: Challenges and solutions," *Computer Communications*, vol. 68, 015, doi: 10.1016/j.comcom.2015.08.004.

[30] C. Boja, P. Pocatilu, and A. Zamfiroiu, "Secure SMS communications for M-learning services," in *Proceedings of the 5th European conference on European computing conference, ECC*, 2011, pp. 480–484.

[31] M. Ridha and K. H. Maharani, "Implementation of artificial intelligence chatbot in optimizing customer service in financial technology company PT. FinAccel Finance Indonesia," in *The 5th International Conference on Vocational Education Applied Science and Technology 2022*, 2022, pp. 1–9, doi: 10.3390/proceedings2022083021.

[32] W. Maeng and J. Lee, "Designing a chatbot for survivors of sexual violence: exploratory study for hybrid approach combining rule-based chatbot and ML-based chatbot," in *Asian CHI'21: Proceedings of the Asian CHI Symposium 2021*, May 2021, pp. 160–166, doi: 10.1145/3429360.3468203.

[33] W. Lehnert, "Human and computational question answering," *Cognitive Science*, vol. 1, no. 1, pp. 47–73, Jan. 1977, doi: 10.1207/s15516709cog0101_3.

[34] U. Gnewuch, S. Morana, Marc, and A. Maedche, "Faster is not always better: understanding the effect of dynamic response delays in human-chatbot interaction," in *Twenty-Sixth European Conference on Information Systems (ECIS2018)*, 2018, pp. 1–17.

[35] M. Dewi and H. Fahmi, "Implementation of AI chatbot application for social anxiety problem," *IT For Society : Journal of Information Technology*, vol. 8, no. 1, pp. 1–5, Aug. 2023, doi: 10.33021/itfs.v8i1.4662.

[36] J. Yin, Z. Chen, K. Zhou, and C. Yu, "A deep learning based chatbot for campus psychological therapy," *arXiv*: 1910.06707, 2019.

[37] P. Z. Rayees, N. Basu, "Achievement motivation of higher secondary school student: a literature review," *International Journal of Advanced Multidisciplinary Scientific Research (IJAMSR)*, vol. 4, no. 8, pp. 37–45, 2021.

[38] O. Blynova, K. Kruglov, O. Semenov, O. Los, and I. Popovych, "Psychological safety of the learning environment in sports school as a factor of achievement motivation development in young athletes," *Journal of Physical Education and Sport*, vol. 20, no. 1, pp. 14–23, 2020, doi: 10.7752/jpes.2020.01002.

[39] L. O. Safihu, P. Bundu, and H. A. Gani, "The effect of achievement motivated students and mastery of information technology on the results of an elementary school teacher competency test," *Asian Journal of Applied Sciences*, vol. 10, no. 3, pp. 301–308, 2022.

[40] W. O. Galitz, *The essential guide to user interface design: an introduction to GUI design principles and techniques*. Chichester: Wiley-Blackwell, 2007.

[41] H R. Hartson and P. S. Pyla, *The UX book : Agile UX design for a quality user experience*, 2nd ed. Cambridge, MA: Morgan Kaufmann, 2019.

[42] F. Espigares-Jurado, F. Munoz-Leiva, M. B. Correia, C. M. R. Sousa, C. M. Q. Ramos, and L. Faísca, "Visual attention to the main image of a hotel website based on its position, type of navigation and belonging to millennial generation: an eye tracking study," *Journal of Retailing and Consumer Services*, vol. 52, p. 101906, 2019, doi: 10.1016/j.jretconser.2019.101906.

[43] T. Neil, *Mobile design pattern gallery: UI patterns for smartphone apps*, Sebastopol, CA: O'Reilly Media, Inc., 2014.

[44] S. Sepp, S. J. Howard, S. Tindall-Ford, S. Agostinho, and F. Paas, "Cognitive load theory and human movement: towards an integrated model of working memory," *Educational Psychology Review*, vol. 31, no. 2, 2019, doi: 10.1007/s10648-019-09461-9.
[45] A. Suttcliffe, "Psychology of user engagement," in *Designing for User Engagment: Aesthetic and Attractive User Interfaces*, A. Sutcliffe, Ed., Cham: Springer International Publishing, 2022, pp. 3–13, doi: 10.1007/978-3-031-02188-6_2.
[46] J. Johnson, "Recognition is easy, recall is hard," in *Designing with the Mind in Mind: Simple Guide to Understanding User Interface Design Guidelines*, J. Johnson, Ed., Cambidge, MA: Morgan Kaufmann, 2020, pp. 143-154.

BIOGRAPHIES OF AUTHORS

Ain Arissa Zainuddin is a postgraduate student who is currently pursuing her master in human-computer interaction at the Department of Multimedia, Faculty of Computer Science and Information Technology, Universiti Putra Malaysia. She received her bachelor of computer science (majoring in multimedia) in 2019 from Universiti Putra Malaysia. She is experienced in designing and developing numerous systems and websites before continuing her postgraduate study. Now she is also an active freelancer as a system analyst, UI/UX designer and web developer. Her research interests include human-computer interaction, education technology, and UI/UX. She can be contacted at email: ainarissa.chedin@gmail.com.

Noris Mohd Norowi is a senior lecturer at the Faculty of Computer Science and Information Technology, Universiti Putra Malaysia, Malaysia. She received her PhD degree in computer music in 2013 from the University of Plymouth, United Kingdom. She studied for her master of science degree in multimedia systems and bachelor of computer science degree (majoring in multimedia) at the Universiti Putra Malaysia, Malaysia. She is a member of the Human-Computer Interaction Lab at the Faculty of Computer Science and Information Technology, Universiti Putra Malaysia. She is an active member of the ACM SIGCHI Kuala Lumpur Chapter (myHCI-UX). Her research interests include music interaction, artificial intelligence in music, immersive technologies, mobile interaction, sound cognition, and sound synthesis. She can be contacted at email: noris@upm.edu.my.

Rahmita Wirza O. K. Rahmat received B.Sc. and M.Sc. degrees in science mathematics from University Science She earned a PhD in computer assisted engineering from the University of Leeds in the United Kingdom. She is currently employed as a lecturer in the Faculty of Computer Science and Information Technology (Prof. in computer graphics). Computer graphics and applications, computer assisted surgery, and computational geometry are among her main research interests. Founder of Computer Graphics and Application Research Group, later renamed Computer Graphics, Vision, and Visualization Research Group, as well as a co-founder of Computer Assisted Surgery and Diagnostic Special Interest Research Group (CASD). She can be contacted at email: rahmita@upm.edu.my.

Mas Nida Md. Khambari is a senior lecturer in instructional technologies, learning design and innovation at the Department of Foundations of Education, Faculty of Educational Studies. Her research interests and specialization include instructional design, innovation and emerging technologies in teaching and learning, gamification, alternative assessment and the scholarship of teaching and learning. She has actively participated and won several medals at innovative teaching and learning competitions at both the university and national level. She was awarded the Putra InnoCreative Award for Best Innocreative Educator (Face to Face Immersive Learning Experience) in 2019 and the Vice Chancellor Fellowship Award in Teaching and Learning in 2020. She can be contacted at email: khamasnida@upm.edu.my.