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BYOD implementation model in Malaysian schools: The perception and readiness of parents, schools, and teachers

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ABSTRACT

The proliferation of digital technologies has brought upon new possibilities in revolutionizing education. Learning is no longer constrained to face-to-face interaction, but it is opened up to a whole new dynamic of interactive online classrooms. Correspondingly, the Ministry of Education Malaysia (MOE) has embarked on the 21st Century Learning, which focuses on technology as an enabler. As such, Bring Your Own Device (BYOD) implementation can be seen as an effective cost mitigation strategy to lessen the government's burden on providing the optimal 21st century pedagogical ecosystem. The previous studies found six important factors of BYOD's implementation, which are infrastructure, safety, knowledge, community, health, and culture. Malaysia is also aiming towards BYOD's implementation; however, the policy is only focused on four factors, namely knowledge, community, infrastructure, and security, with limited descriptions of each factor. Therefore, this paper aims to discuss all the identified factors and propose a model to implement the BYOD implementation at school. This is a two-pronged study in which an optimal BYOD implementation model is proposed and subsequently, a quantitative analysis on the perception and readiness of schools, teachers and parents towards BYOD is discussed. Due to the disruptive nature of BYOD, the majority means of parents' responses lean more towards the negative spectrum of the Likert scale. Hence, several proactive recommendations are suggested to ensure BYOD a fruitful pursuit.

1. Introduction

Innovation in education entails the orchestration of change management, technology, and pedagogy as its prime movers for success. Over the years, several key technologies (including mobile technologies) have been implemented to shape our pedagogical landscape. In the pre-digital years, circa 1972, TV Pendidikan (TVP), or educational TV was conceived (Baker, 2014). In the 1980s, teaching aids were highly encouraged as a more effective pedagogical technique to engage pupils. This was enforced by the Ministry of Education Malaysia (MOE) through New Primary School Curriculum (Kurikulum Baru Sekolah Rendah or KBSR) and Secondary School Integrated Curriculum (Kurikulum Bersepadu Sekolah Menengah or KBSM). Comes the millennium, information, communication, and technology (ICT) evolution has led to the digitalization of education. Traditional learning aids have been digitally reinvigorated to spark learning interests in young people. Digital content is far more engaging and captivating than traditional learning aids and, as such, may foster positive learning outcomes. In line with that perspective, smart school initiative was introduced later in the 2000s as one of the seven flagship applications for Malaysian Super Corridor (MSC) (Alberta Education, 2012). Schools were provided with necessary infrastructures, including computer laboratories, human resources, and digital curriculum. In the year 2014, 21st Century Learning (Pembelajaran Abad 21 or PAK21) was introduced to better equip students with 21st century skills. These anecdotal timeframes briefly describe the gradual shifts of a pedagogical method through the lens of

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technological changes, from being teacher-centric in the yesteryears towards student-centric in PAK21.

MOE acknowledges that PAK21 encompasses more than the use of the latest gadgets, hardware, and software in the classroom, in which teachers should employ student-centric teaching and learning methods to sharpen their students' higher-order thinking skills. Furthermore, MOE has outlined five basic standards for PAK21, i.e., communication, collaboration, critical thinking, creativity, and values and ethical applications. These are the much sought after 21st century skills to be groomed alongside the capability to use digital or Internet technologies to solve posed assignments in the classroom. For example, students are required to produce an innovative solution for a particular scientific problem. In this student-centric approach, it may require extensive online researches, rapid exchange of information, and creative multimedia presentations. Compared to desktop computers, the immediate availability of mobile devices (smartphones, tablets) is seen to be more convenient and ergonomic to support collaborative learning (Chigona and Chigona, 2010; Al-Qaraghuli et al., 2011). It provides a platform for one-to-one interaction and seamless connectivity between students and teachers making it more engaging than traditional methods.

Realizing this, the gradual shifts of classroom desktops to mobile devices to ensure one-to-one access ratios are becoming more common worldwide (Christopher, 2016). There have been two emerging forms of technology providers to ensure a one-to-one ratio of student access (Christopher, 2016). The first form involves funding from the government, which exerts huge financial pressure on the government. The second form requires parents or guardians to provide the device to their children, which is termed as Bring Your Own Device (BYOD), that will be discussed further in section 2.

2. Bring your own device

BYOD, in this regard, refers to technology provision models where students bring and use their own personal devices for educational purposes similar to how books are used in classrooms (Christopher, 2016). In this context, examples of mobile devices are laptops, mobile phones, tablets, etc. There are various models for BYOD which have been identified in the literature. Romrell et al. (2014) outlined five models for BYOD, as discussed in Table 1.

Table 1: BYOD models

BYOD Model	Description
(1)School defined single platform laptop or tablet.	Students are required to procure their own devices from a set of standardized or minimum specifications set by the school.
(2)School-defined single platform laptop, plus another device.	Similar to the above, with the allowance of an extra device, e.g., a smartphone.
(3)School-defined multi-platform laptops.	The only difference between Model 1 is that it allows several platforms or manufacturers.
(4)Student-choice of laptop or tablet.	Students are allowed to bring any form of laptops (e.g., netbook) with full PC capability, or a tablet. 100% of parents funded.
(5)Bring your own whatever connects to the Internet.	General and loose definition of BYOD, any Internet-capable devices are allowed—smartphones, laptops, tablets, e-books, etc. 100% parents funded.

2.1. Other emerging and successful BYOD implementation

There is a common theme among BYOD implementation discovered by other researchers and proven by various successful BYOD programs. Due to the disruptive nature of BYOD, the key to managing this change is collaboration. BYOD success is determined by the cohesiveness of the stakeholders' collaboration to achieve a common goal of fostering a student-centric learning ecosystem. This goal will directly determine which model to adopt, the infusion of technological pedagogy-based factors selection, infrastructure and security, and professional development.

2.1.1. Collaborative planning

"The communication with the school community (i.e., students, parents, community groups, and other stakeholders) is tremendously important if the plan is to have strong community support and sustainability. The community needs to be involved in every step of the way". In this respect, Alberta Education (2012) Education has described a very holistic and practical guide (Falloon, 2015). At the very least, full cooperation between the trio of key stakeholders (teachers, students, and parents) is mandatorily critical. A study in New Zealand primary schools emphasized the significance of collaboration between the trio stakeholders (Hwang et al., 2008). Another New Zealand secondary school study resonates with the same concern, in which the major challenge needed to be redressed swiftly was change management and student management (Inman, 2012). While; Christopher (2016) attributed BYOD success to a larger scope of holistic cooperation between the trio stakeholders, school administration, as well as external community entities. This close collaboration will help determine the appropriate model and subsequent technologies and policies that follow.

2.1.2. Model selection

There are five types of models to be considered if schools want to adopt BYOD implementations, which are Model 1-Single Platform Only, Model 2-Single

Platform and Device, Model 3–Multi Platforms, Model 4–Cross Platforms, and Model 5– All platforms. According to Ross (2013), the selection can be decided based on stakeholders' collaborative engagement. The model's description is described in Table 2.

Table 2: Benefits and consideration for various BYOD models

BYOD Model	Benefits	Consideration
Model 1 – Single Platform Only School defined single platform laptop or tablet.	Common device capabilities. Promotes efficient teaching and learning where teachers can plan their lessons based on these homogeneous device capabilities. Volume buying power that saves costs.	Parents' financial capabilities need to be gauged and taken into account.
Model 2 – Single Platform + Device School-defined single platform laptop, plus another device.	The supplementary device adds flexibility and personal freedom, a way to "legalize" smartphones use in schools.	Distraction from the supplementary device. Requires stricter policies to guarantee the appropriate use of devices and infrastructures.
Model 3 – Multi Platforms School-defined multi-platform laptops. The only difference between Model 1 is that it allows several platforms or manufacturers.	Freedom of choice for parents and students within the school's constraints.	Careful considerations in infrastructure and policy planning. Teachers and technical staffs need to be knowledgeable on several platforms. Bulk buying power is severely reduced.
Model 4 – Cross Platform Student-choice of laptop or tablet. Students are allowed to bring any form of laptops (e.g., netbook) with full PC capability, or a tablet. 100% of parents funded.	Extra freedom of choice for students and parents.	With a virtually unlimited choice of platforms, teachers and technical staff need to be adequately trained. Cross-platform support for e-learning tools cannot be guaranteed. Inequity concerns.
Model 5 – All Platforms Bring your own whatever connects to the Internet. General and loose definition of BYOD, any Internet-capable devices are allowed—smartphones, laptops, tablets, e-books, etc. 100% parents funded.	Total freedom for students and parents.	Diverse variety of devices and platforms adds complexities that may hinder learning processes. Inequity concerns. Software virtualization and cloud computing to mitigate configuration complexities.

Based on Table 2, about 100% of parents-funded models will likely raise inequity issues endemic in high economic disparity societies. Stakeholders need to address this issue into their considerations. However, it is interesting to note that, "students who do not have personal technology devices have greater access to school-owned technology tools when students who bring their own devices to school are no longer competing for that access" (Ross, 2013).

The device itself is not the sole focal point in BYOD. It must be made integral to the teaching and learning activities; only then could it promote pedagogical enrichment (Intel Education, 2014). As such, there is no one-size-fits-all model solution. Each model caters to different configuration variance in a particular environment. All parties involved need to strive together in finding a workable and optimal balance between freedom and physical or financial constraints. Careful planning is critical, as put forward by Alberta Education (2012) Education (Ross, 2013), "one of the key strategic steps each school authority should take, prior to making this decision, is to clearly articulate its goal(s) for opening up schools and classrooms to personally owned devices."

In this respect, Oak Hills's execution is an outstanding example. The key principle of the district's approach is the active community/stakeholder participation, which "actively try to create an environment that will work with any device," in this context, a Model 1 and 5 hybrids are considered as an ideal model. Schools and local community demographics data (e.g., household income, parental support) were collected and taken into account to determine the best technology procurement options.

2.1.3. Pedagogy-based technology infusion

Many models have been developed in the context of incorporating technologies in instructional designs. This paper discusses two models, which are Delivery, Student Practice, Assessment, and Productivity Framework (DSAP) and Substitution, Augmentation, Modification, and Redefinition Model (SAMR) Model. The DASP framework can work as a tool to scaffold teachers to implement 21st century learning (e.g., blended learning) in which technology will merge content and pedagogy with strong connections and SAMR model as an evaluation tool that help teachers to address the effect of technology integration. Using these frameworks, teachers can analyze learner's characteristics and capability to differentiate students to meet the end of learning's goals.

Fig. 1 shows a DSAP Framework consists of four major areas where technology can be used in teaching and learning. It serves as a quick start guide for BYOD pilot teachers to integrate technology in ways that improve teaching and learning efficacy (McLean, 2016). It can also be used as an evaluation tool to measure the impact of BYOD in the classroom. A study has shown that teachers acknowledged this framework positively (McLean, 2016). This study also found that BYOD had a positive impact on the use of technologies in the classroom. DSAP Framework is being used by the Wake County Public School System to produce an "engaging, personalized, and meaningful" learning environment.

Each tool runs on specific or various platforms, with different levels of access and terms of services (TOS). Hence, they may require age-based student account registrations that impose granular parental permission and awareness, which should be addressed in the school's standardized policies and workflows. Some examples of the tools are shown in Table 3.

Fig. 2 describes the SAMR Model, which is more structured and instructional ways of incorporating technologies in the classroom (Kim et al., 2008). It can also be used to evaluate how far technology has transformed learning. It is comprised of four areas in which technology can be used in a classroom:

Substitution: Technology provides a direct alternative for other learning activities without functional change. Example: Reading a book on a tablet.
Augmentation: Technology provides a more effective substitution for other learning activities, with functional improvements. Example: Online quizzes provides instant feedback instead of paper and pencil.
Modification: Technology allows the significant transformation of learning activities. Example: Multimedia presentation.
Redefinition: Technology allows learning activities that are previously unattainable without the use of technology. Example: Collaborative mind mapping.

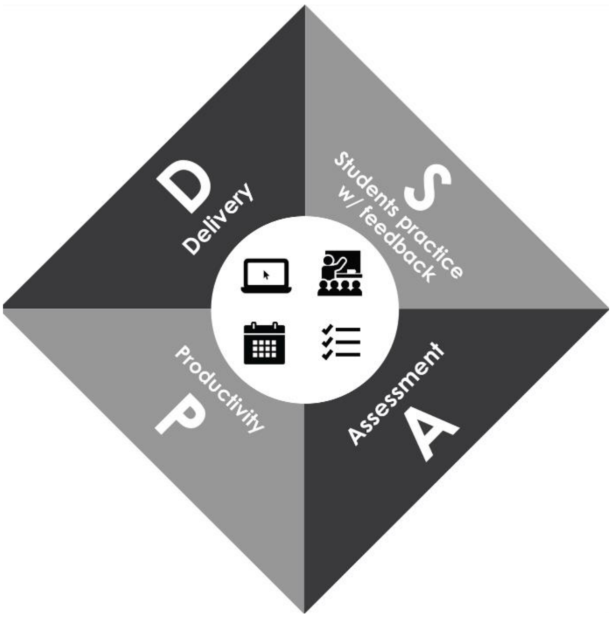

Fig. 1: Delivery, student practice, assessment, and productivity framework (DSAP)

Table 3: Examples of teaching and learning tools for DSAP

Activities	Description	Examples of Tools
Delivery	Used by teachers to disseminate study materials	Blackboard, Edmodo, EdPuzzle, Prezi
Student practice with feedback	Allows students to practice lessons	Animoto, Edmodo, Google Apps for Students, ARIS
Assessment	Platforms for teachers to assess student learning	Brainpop, Socrative, Kahoot.it, Google Forms
Productivity	Helps students to be more productive and organized in self-directed ways towards learning goals, e.g., taking notes	Bit.ly, Edmodo, Evernote, Wunderlist, Google Calendar, Diigo

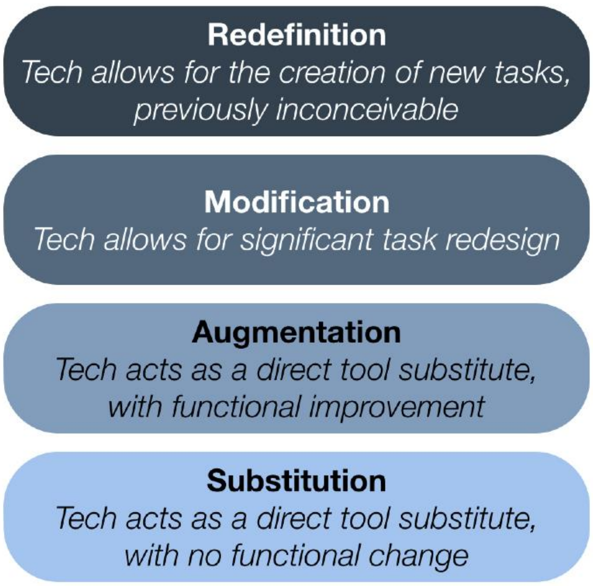

Fig. 2: Substitution, augmentation, modification and redefinition model (SAMR)

2.1.4. Pedagogy-based form-factor selection

Table 4 depicts the computing capability taxonomy, which was adapted from Dixon and Tierney (Fullan, 2012). As the technology matures, the capabilities are strictly unrestrictive, but it drives home the point that stakeholders need to carefully consider the capabilities of the devices they recommend to be aligned with pedagogical goals.

2.1.5. Infrastructure and security

There is no one-size-fits-all BYOD technical implementation too. Each school is unique in terms of its size, campus type, mobile devices, pedagogical and institutional goals, usage access policies, etc.

Intel Education (2014) suggested, "an effective BYOD program will actively try to create an environment that will work with any device" (Ahmad et al., 2018). Device independence can be achieved through desktop virtualization software that connects to an "education as a service" cloud. Cloud computing is the future, as a study on Austrian schools has found. This is also implemented in Oak Hills district schools, where teaching materials and software tools are stored centrally in the cloud (Ahmad et al., 2018).

Table 4: Computing capability taxonomy adapted from Dixon and Tierney

Sample capabilities	Smartphone	Tablet	Laptop	Tablet PC
Internet-based researches	X	X	X	X
Multimedia (voice/audio/video) recording and editing for conferences/collaboration	X	X	X	X
Supports minor typing tasks	X	X	X	X
Supports longer typing tasks ergonomically	External keyboard	External keyboard	X	X
Multitasking for extensive researches	High-end models	High-end models	X	X
Supports full-fledged web and graphic design software, CAD		High-end models	X	X
Supports programming and handwriting recognition for Math, Music, Chemistry				X
Note-taking with a digital pen				X

One of the largest and common concerns found by several European countries while implementing BYOD is the challenges of keeping up technical feasibilities of the tools with pedagogical goals. If the pedagogical objectives cannot be met, BYOD simply should not proceed, e.g., if sufficient bandwidth connection cannot be provided.

Schools with 100% BYOD implementation must be equipped with a robust Internet connection. Capacity planning must be carried out accordingly upon the institution size, campus type, number of users, etc. Adequate Wi-Fi hotspots must be installed to accommodate surges and strategically positioned to minimize radio interference. NEN-The Education Network in the United Kingdom (UK) put forth a 2Mbps rule of thumb per connected device. While in the United States (US), based on extensive research across eight states, the State Educational Technology Directors Association (SETDA) categorizes bandwidth requirements according to district size (Table 5). This requirement is projected to triple every three years.

Table 5: K-12'S recommended bandwidth for BYOD in the US

School Year	2017-18 Targets	2020-21 Targets
Small School District (fewer than 1,000 students)	At least 1.5 Mbps per user (Minimum 100 Mbps for the district)	At least 4.3 Mbps per user (Minimum 300 Mbps for District)
Medium School District Size (3,000 students)	At least 1.0Gbps Per 1,000 users	At least 3.0 Gbps per 1,000 users
Large School District (more than 10,000 students)	At least 0.7 Gbps per 1,000 users	At least 2.0 Gbps per 1,000 users

Network connectivity is critical, especially upon certain BYOD models. In the case of the Oak Hills district schools, a "one-stop-shop" portal was developed, where students, teachers, and parents connect through this district-owned private clouds through wireless networks to access study plans and web-based e-learning applications (Ahmad et al., 2018). So, lesson plans could be brought to a complete halt in case of a network breakdown.

From a logistical and operational view, managing thousands of mobile devices can be a nightmare. Among the choices for identity and safety management are sophisticated tools, e.g., Mobile Device Management System (MDMS) or Mobile Application Management Systems (MAMS). MDMS and MAMS are a suite of software that alleviate the complexities of maintaining and monitoring mobile devices through a central location. Applications, configuration settings, data, patches, and even digital textbooks can be deployed efficiently Over the Air. The major difference between the two is that MDMS requires intrusive on-device client installation. So, MDMS could pose privacy issues as it may have broad access to any or all communication channels on the device, although the risks are largely misunderstood (Murray and Olcese, 2011). While MAMS offers application-level encryption via application sandboxing or containerization to mitigate data leaks risks.

The mandatory enforcement of usage access policies is not a replacement for these costly suites. Combined with continuous digital citizenship education programs, it will help ensure the ethical and safe utilization of the infrastructure. Policies should also cover the physical safety of the device from theft and distraction.

2.1.6. Professional development

21st century learning activities demand a high level of independence from the students in handling mobile technologies. However, dealing with laggard students would require additional teacher assistance to keep them on track. Hence, teachers are expected to be technologically savvy. It is quite a daunting task, but in contrast to popular belief, professional development planning in education must not focus on the technology itself. Based on several BYOD implementation types of research, Inman (2012) concluded that BYOD programs that rely heavily on technologies instead of pedagogical goals would fail (Parsons and Adhikari, 2016).

Therefore, professional development programs should be strategically tailored and transformative to accommodate 21st century learning approaches. This requires the materialization of a strong school administrative leadership and vision through the formulation of skills development policies and on-going monitoring schemes (Atoum and Al-Hattab, 2015). Schools may provide sponsorships to seminars and workshops to reduce financial burden imposed on the teachers as well as to gain traction. However, teachers may not have enough windows of time to attain sufficient skills. To remedy, Uche et al. (2016) recommended teachers engage with more competent colleagues to form self-development groups, as well as to spark interests.

Several technology acceptance studies concluded that behavioral intention is positively influenced by its perceived usefulness (Ogie, 2015). In this context, learning and technology infusion is largely motivated by the attitude of teachers towards the technology itself (Reed et al., 2017). Using the well-known Davis's (1989) Technology Acceptance Model (TAM), a recent empirical study found that there is a direct and significant positive causal relationship between BYOD's premises of instant connectivity, compatibility, interaction, and content enrichment and its perceived usefulness. This implies teachers indeed perceive BYOD as useful in pedagogical senses due to its ease of use, though many of them are more conservative. Thus, investigating the gaps between teachers' perception of technology and skills attainment is important to gauge and instill their confidence, as well as providing insights for better practices and training programs.

Based on the literature, for an emerging environment like ours, BYOD should be treated as a continuous change management program. Since each locality has distinct perceptions and requirements on technologies, proper strategy and proactive local community engagement are required to reduce resistance and ease acceptance.

In addition, BYOD should also be implemented along with other critical enablers. A study has pinpointed a few factors that could affect BYOD implementation, namely BYOD related health issues, and financial capability.

2.2. BYOD in Malaysia

BYOD in Malaysia has gone through several, albeit piecemeal evolutions, from 1Malaysia Netbook to "1 Laptop 1 Student", to Chromebook. 1Malaysia Netbook is tailored towards secondary school students from underprivileged households, in which 1,668,772 units of netbooks have been distributed all over Malaysia. While the Chromebook initiative has been implemented by MOE since April 2013. It was implemented to ensure equal Internet access among students through the Virtual Learning Environment (VLE) called 1BestariNet. 1BestariNet is the teachers-students cloud-based information exchange platform that accommodates ubiquitous learning. Ubiquitous learning is the environment that supports constant learning regardless of physical or time constraints (Luo and Murray, 2018) through the application of mobile devices, in this case, the Chromebook devices.

Recently, in March 2018, a memorandum that specifically addresses BYOD implementation in schools has been released (Uche et al., 2016). It outlines a number of general policies for implementing BYOD. For instance, only laptops, tablets, audio players, or any other "future" devices that resemble the function of a laptop is allowed. Interestingly, mobile phones/smartphones are still prohibited, in contrast to several implementations of BYOD in Europe. A few models of device provision are also suggested, which includes funding by guardian/parents, PTA/school sponsorship, or third party donation (agencies/organizations/ individuals). Other important things outlined are operating procedures such as device registration, safety, and management. All in all, the emphasis is placed on the close cooperation between all parties involved. In other words, MOE implicitly acknowledges the significance of these critical stakeholders, namely schools, teachers, the Parent Teacher Association (PTA), parents, and students. This puts Malaysia in the right direction with other BYOD implementation worldwide. However, the guidelines are rather superficial, where no research has been undertaken on stakeholders' perception and readiness to accommodate BYOD. Therefore, this study investigates these factors as part of the proposal for an optimal BYOD model for the Malaysian school ecosystem.

3. Methodology

In order to underpin the relevant factors that make the foundation of an optimal BYOD model for Malaysian schools, a mixed research methodology was employed. Four phases were involved, which are illustrated in Fig. 3.

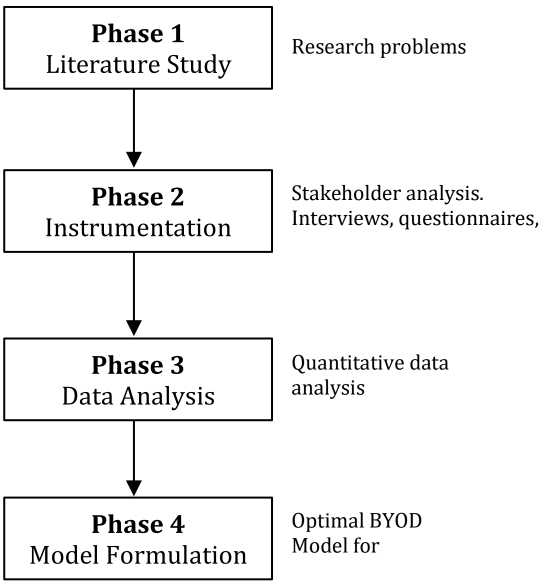

Fig. 3: Research methodology

A stakeholder analysis was conducted to explore possible factors that affect BYOD implementation in schools, as outlined by the key elements, as shown in Table 6.

Table 6: Roles and impact of stakeholders

Stakeholders	Roles	Potential Impact
Ministry of Education	Develop and implement BYOD policies and oversees budget allocation for schools' infrastructures.	High
Teachers	Facilitate effective and engaging teaching and learning techniques via BYOD	High
Parents	Provide consent and financial provision of mobile devices for their children and foster healthy cybersecurity lifestyles	High

After conducting the analysis, three types of instrumentations were deemed appropriate to gather valuable input for this research, i.e., questionnaire, interview, and closed forum.

3.1. Interview

Two interview sessions were conducted with Cyber Security Malaysia (CSM) and Education Technology Division, MOE. The objective of the CSM session was to keep abreast of the latest updates regarding their national awareness programs. The session with MOE was carried out to enquire further information about its 13th initiative, Virtual Education, in the Interim Strategic Plan 2011-2020.

Additionally, to complement the questionnaire, a total of four one-to-two-hour interview sessions with the management team, ICT teachers and technicians in three schools were conducted.

3.2. Questionnaire

Two distinct sets of questionnaires (Set A and Set B, henceforth) were constructed and distributed manually and on-line based on the two specific stakeholders, namely teachers and parents. All questions are closed-ended on a Likert scale of 1: Strongly Disagree, 2: Disagree, 3: Simple Agree, 4: Agree. 5: Strongly Agree.

The population sample for Set A is 300 teachers at five primary and secondary schools in Putrajaya and Dengkil. However, only 68% of forms are used for quantitative analysis using SPSS. The set is composed of five components, i.e. (A) General profile of the respondent, (B) School infrastructure availability and readiness of school implement BYOD in their school, (C) Preparation of security controls safely, (D) Level of teacher knowledge and readiness applying BYOD and (E) Teacher's opinion(s) on health issues if BYOD is implemented. The main objective of this set is to quantify schools' and teachers' levels of readiness in carrying out BYOD.

Set B is tailored towards parents with children aged 17 years and below in order to gauge their perception and readiness on BYOD implementation (Ng, 2015).

It was manually distributed to schools in Putrajaya, Dengkil, Bandar Baru Bangi and Kajang. The online version was disseminated all over Malaysia through Whatsapp and email. Overall, there are 872 participants in which 69.2% completed the form manually while the remaining did it online. There are eight sections namely (A) General Profile, (B) ICT and Internet Facilities at Home, (C) Cyber Security Knowledge and Awareness, (D) Children's Personal Virtues while Using the Internet, (E) Authoritative Parenting Style, (F) Cyber Usage Home Monitoring, (G) Safe Cyber Usage, and (H) BYOD Suggestion. Only Section A and H are relevant to this study. Five basic questions were asked, namely:

i. I agree with the proposal to implement BYOD in schools.
ii. I agree to provide Internet-enabled mobile devices as learning tools.
iii. I agree to provide Internet packages with parental control tools.
iv. I prefer my children to use the school's provided Internet infrastructures.
v. BYOD is a burden to me as a parent.
vi. I am satisfied with the school's cybersecurity information sharing.
vii. Schools should build more rapport with parents to promote greater cybersecurity awareness.

3.3. Closed forum

A 40-minutes "Cybersecurity: Towards a Secure and Sustainable Cyber Use" closed discussion was conducted at UKM. The objective was to exchange input and views on the government's efforts to promote healthy cyber lifestyles among Malaysians. Among the participants were representatives from Royal Malaysia Police, Ministry of Women, Family and Community Development, Ministry of Education, Ministry of Communications and Multimedia Commission, Faculty of Law, Universiti Kebangsaan Malaysia, and the National Occupational Safety and Health Institute. Subsequent presentations were reinforced by 10-minutes questions and answers session.

4. Analysis result

This section discusses the findings from the instrumentation tools stated in the previous section. The mean values represent readiness levels of a particular factor, namely: 4.00–5.00: High, 3.00–3.99: Medium, 2.00–2.99: Low, 1.00–1.99: Very low, 0.00–0.90: Not available.

4.1. School infrastructure

The findings in Table 7 concludes, schools' facilities are seemed to be not ready for BYOD. Basic critical infrastructures such as internet connection, Wi-Fi, power sockets are deemed inadequate to support such an ecosystem. This is further negated by the lack of basic amenities such as tables and chairs. In the interviews, teachers described existing tables and chairs are non-ergonomic for prolonged use of mobile devices. In addition, given the explorative nature of young students, content filtering is urgently needed, which is on a medium preparedness level. Incidentally, the study recorded a very high mean of the score for the need of ICT technicians, almost unanimously at 96.6% of all respondents. Teachers further corroborated in the interviews that they are obliged to assume the responsibilities of a technician in keeping devices well maintained, which hinders teaching efficacy.

4.2. Health impact

Table 8 shows the details for the means of scores for five topics related to pathological gadgets or Internet use. In summary, the majority of responses lean towards the negative ends of the Likert scale, which can be alarming, especially to young students in their vulnerable formation years. The finding confirms to past studies that correlate Internet addiction with psychosocial and physiology problems (Ng and Cumming, 2015; Hu et al., 2016; Yeop et al., 2018). Almost all or 96.6% of respondents collectively conceded that the excessive use of gadgets and Internet addiction might contribute to other negative symptoms. 86.3% of respondents observed that students lose focus, and 91.2% recorded that some may even fail to complete their homework on-time. 81.9% of respondents also believed that it might contribute to eye conditions such as myopia or may even lead to blindness in extreme cases.

4.3. Safety

Table 9 shows four pre-requisite requirements of safety control for BYOD implementation. It can be concluded that the needs for these elements are quite critical, ranging from medium to high. A very high percentage of respondents collectively agreed that mobile devices' specifications should be dictated by the school; all devices should be pre-registered and safeguarded with anti-virus software in a secure confinement of a closely monitored Wi-Fi. This is to ensure all resources concerned are strictly used for educational purposes only.

Table 7: Readiness of school facilities for BYOD

Topic	Mean	Std. Deviation	Readiness Level	Agree%
Internet Connection	2.76	1.111	Low	62.8
Wi-Fi Connection	2.55	1.28	Low	45.5
Content Filtering	3.11	1.2	Medium	76.5
Power socket in Classroom	2.44	1.167	Low	40.2
Tables and Chairs	2.83	1.252	Low	58.3
Safety Locker	2.81	1.402	Low	57.4
The need for ICT Technician	4.5	0.833	High	96.6

Table 8: Risks of excessive use of gadgets and internet

Topic	Mean	Std. Deviation	Level	Agree (%)
Blindness due to excessive use of gadgets	3.73	1.098	Medium	81.9
Tired, sleepy or lost focus in the classroom	3.78	0.978	Medium	86.3
Failure to complete the schoolwork	4.03	0.898	High	91.2
Different attitude when at home and at school due to internet addiction.	3.82	0.892	Medium	92.7
Uncontrolled gadgets and internet	4.08	0.78	High	96.6

Table 9: The need of safety control

Question	Mean	Std. Deviation	Level	Agree (%)
Device spec. determined by school	3.84	1.094	Medium	90.2
Device registration	4.06	1.126	High	90.2
Guarded with Anti-virus	4.32	0.771	High	97.1
School Wi-Fi only	4.21	1.122	High	88.2

4.4. ICT knowledge and skills

Table 10 shows that teachers' levels of knowledge regarding the government's initiatives on cybersecurity and cyber law are on a medium level. Nevertheless, they are highly aware that the Internet is a valuable source of information that can be tapped for pedagogical enrichment. 89.7% of teachers also possess highly moderate skills in handling mobile devices, which can be handy in assisting students in the classroom.

Table 10: Level of teacher's knowledge

Question	Mean	Std. Deviation	Level	Agree (%)
Knows about awareness program related to cybercrime and cyber ethics	3.89	0.724	Medium	95.6
Materials on the Internet can be used as a learning tool	4.42	0.665	High	98
Skilled teacher who can handle laptops, tablets or iPad	3.84	0.961	Medium	89.7
Skilled teacher in cybersecurity knowledge and its threats	3.59	0.991	Medium	89.3

4.5. Perception and readiness of parents

The first question can be used as a proxy for overall parental perception and readiness on BYOD implementation at school. Table 11 shows an alarmingly low percentage of overall BYOD consent from parents at only 26.9%. This overall, relatively low acceptations level can be ascribed to local socio-economic factors intrinsic in the sample data.

Less than half of parents (40.9%) agreed to provide Internet-enabled mobile devices as learning tools in the classroom. About 35.2% of parents, too, felt that BYOD implementation is a burden for them, due to the fact that almost half (40.9%) of the parents earn below RM3900. However, more than half (59.8%) of parents agreed to provide mobile Internet packages with parental control tools. This is because 80.5% of the parents realize that cybersecurity threats are real and that the software is critical in ensuring safe Internet usages. Almost a majority of parents (70.9%) prefer their children to use school-provided Internet infrastructures for formal learning purposes.

Table 11: Parents' readiness for BYOD implementation

Question	Mean	Std. Deviation	Level	Agree (%)
BYOD consent	2.8192	1.29867	Low	26.9
Will provide Internet-enabled mobile devices as learning tools	3.2836	1.08944	Medium	40.9
Will provide Internet packages with parental control tools	3.6368	1.04027	Medium	59.8
Use school's provided Internet infrastructures	3.9701	0.96918	Medium	70.9
BYOD is a burden	2.8474	1.20489	Low	35.2
Satisfied with the school's cybersecurity information sharing	3.2720	0.91626	Medium	37
Schools should build more rapport to promote greater cybersecurity awareness	3.8176	0.85680	Medium	72.3

The premise of a centrally-controlled and safe-guarded networking ecosystem offers more convenience and peace of mind for parents, without incurring additional costs. A total of 63% of parents raised their concern about cybersecurity information sharing being lackadaisical on the schools' part, while only 37% were satisfied. As a result, almost a majority of 72.3% of respondents indicated that schools should build more rapport to promote greater cybersecurity awareness. This school-parent collaboration is vital to ensure accurate information is being passed down to their children so that safer cyber lifestyles can be nurtured and practiced both at home and school.

5. Discussion

5.1. BYOD implementation model formulation

Factor validation analysis was carried out to validate factor measurements through regression test methods. Prior to the validating process, the factors were extracted and analyzed from the thorough literature review and verified by respondents through the survey technique. Table 12 lists the summary of factors.

Table 12: Summary of extracted factors

Factor	Reference
Knowledge	Sherer and Shea (2011); Attewell (1992); McKnight et al. (2016); Kamalludeen et al. (2016)
Infrastructure Availability	Attewell (1992); Alberta Education (2012); Selwyn et al. (2017)
Safety and Security	Attewell (1992)
ICT Knowledge and Skills	Closed Forum
Health Impact	Hassan et al. (2012)

The factors validation involved is infrastructure availability, health impact, knowledge and ICT skills, and safety control. Linear regression tests with the Stepwise method were executed, with infrastructure availability, health impact, ICT knowledge and skills, and safety and security as its independent variables, and safe use of BYOD as a dependent variable. Table 13 depicts the statistically significant general linear model (R=52.3%, P=0.006). The results show that the four factors are significant in predicting the safe use of BYOD in schools. These factors account for 52.3% of the variances in the safe use of BYOD in schools, with the highest R^2 value of 0.523.

Table 13: Regression model

Factor	R	R^2	SD	Δ Statistical				
				ΔR^2	ΔF	df1	df2	ΔValue F
1	0.538	0.290	0.286	0.290	82.361	1	202	0.000
2	0.685	0.469	0.463	0.179	67.695	1	201	0.000
3	0.710	0.504	0.496	0.035	14.151	1	200	0.000
4	0.723	0.523	0.513	0.019	7.829	1	199	0.006

1- Infrastructure availability, 2-Health impact, 3-ICT knowledge and skills, and 4-Safety and security

Table 14 shows the beta (ß), standard deviation, t, and P-value, with the highest value of ß is Safety and Security factor, followed by infrastructure availability, safety and skills, and health impact.

Therefore, a structural model for BYOD implementation is constructed, as shown in Fig. 4. The ranking of the factors is determined based on the ascending order of its beta weights, which indicate the strength of the relationships between the constructs.

A safety factor is ranked first, followed by infrastructure availability, ICT knowledge and skills, and lastly, health impact knowledge. Thus, it strongly implies that security should be made a prerequisite for the BYOD program in Malaysia that requires proper technology infrastructure and relevant skills attainment, with regard to being health-conscious.

Table 14: Correlation coefficients

Factor	Beta	Std. Deviation	t	P
*(Constant)	-0.266	0.314	-0.847	0.398
Infrastructure Availability	0.351	0.042	8.459	0.000
Safety and Security	0.427	0.055	7.768	0.000
ICT Knowledge and Skills	0.170	0.042	4.037	0.000
Health Impact	0.119	0.043	2.798	0.006

* Dependent variable=Safe use of BYOD at schools

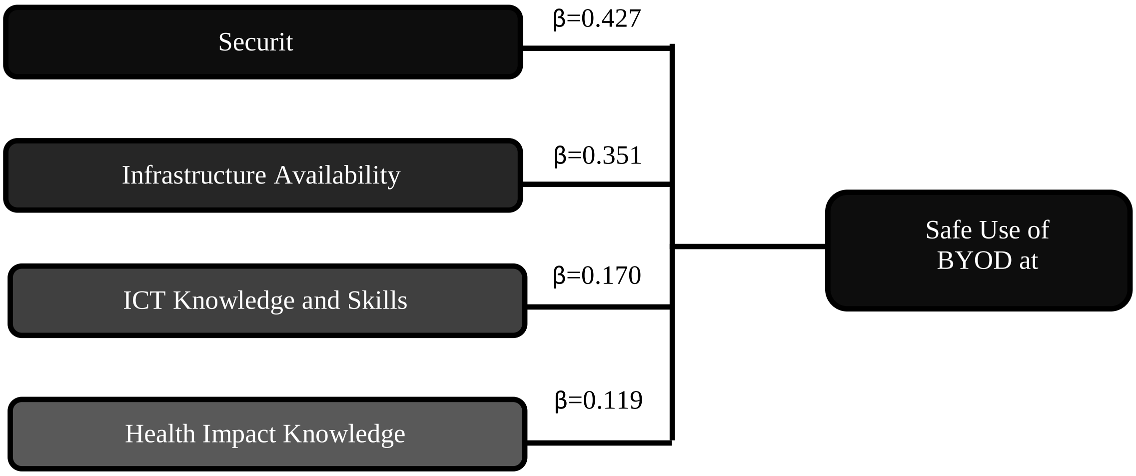

Fig. 4: Ranking of factors for implementing BYOD at school

5.2. Proposed BYOD implementation model at school

Finally, a BYOD implementation model was constructed posterior, as shown in Fig. 5. The model proposes security factors as the foundation for a safe BYOD implementation, enabled by a proper technology infrastructure, empowered by knowledge and skills in ICT, and sustained by health awareness. In order to alleviate the risks introduced by the disruptive nature of BYOD, these technological aspects should be managed through holistic and persistent collaborative leadership. This collaborative cohesion will help ease stakeholders' acceptance and readiness, seeking common pedagogical goals, financial and infrastructure provision strategies, as well as solving issues, optimal for a particular school demographics.

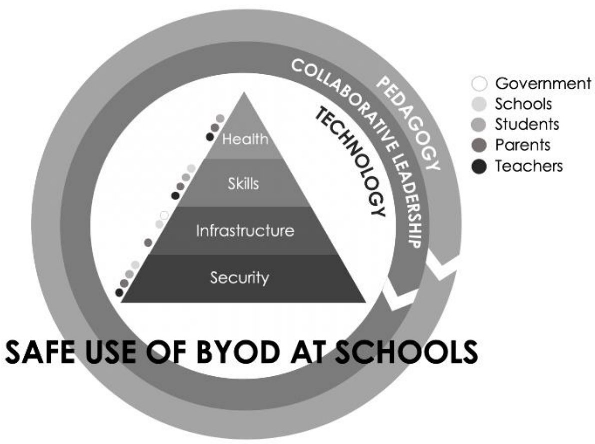

Fig. 5: Proposed BYOD model for Malaysian schools

6. Conclusion

The latitudinal analysis of the multiple surveys conducted with several stakeholders has provided us unprecedented beneficial insights into how well the stakeholders perceive BYOD. The most promising result of our findings showed that there was a very high level of security awareness among stakeholders. The majority of the response with respect to skills and health-related factors were also moderately positive. However, this was negated by poor school infrastructure preparedness. Adding to the blow was the fact that parents were simply not ready, as recorded by our survey. Thus, BYOD should not commence at a full scale, as suggested by the literature. BYOD should be implemented in stages or pilot program to ease acceptance and reduce resistance.

Based on the coalescence of the four beta coefficients and wisdom from literature, a BYOD implementation model for Malaysian schools was proposed. Our model suggests implementing BYOD as a continuous change management program to ensure BYOD achieve its potential benefits, rather than introducing risks. However, being a cross-sectional study, further longitudinal researches from more diverse socio-demographic settings are required, so that we can determine a more holistic perception and readiness of BYOD in Malaysian schools, especially on improving parents', teachers and students with cybersecurity awareness, cooperation to monitor mobile devices content and usage, follow the security best practices and improved the cyber law punishment processes.

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Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflict of interest.

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