# A TAXONOMY OF DIGITAL LEARNING ACTIVITIES FOR DIGITAL INCLUSION

*Research paper*

Nguyen, Andy, University of Oulu, Oulu, Finland, andy.nguyen@oulu.fi

Hong, Yvonne, University of Auckland, Auckland, New Zealand, e.hong@auckland.ac.nz

Gardner, Lesley, University of Auckland, Auckland, New Zealand, l.gardner@auckland.ac.nz

## Abstract

*Governments across the globe have declared digital inclusion as a critical element in their growth strategies. The rapid digitalisation of our lives, including work, education, and social life, has given opportunities and challenges to digital inclusion in our information society. Among all aspects of digitalisation, technology-assisted learning (TAL) has been recognised as a potential platform for digital inclusion. Despite its increasing importance for sustainable economy and society, there is a few structuring of the heterogeneous varieties of educational technologies for digital inclusion. This paper examines the relationship between digital inclusion and TAL activities through the conceptualisation of their characteristics and the creation of a taxonomy of digital learning activities for digital inclusion. The study presents a conceptual framework for key dimensions of digital inclusion. The proposed taxonomy acts as a tool for as-sessing digital inclusion needs related to TAL activities and reflecting TAL intervention on digital inclusion.*

*Keywords: Digital inclusion, e-learning, educational technology, social inclusion.*

# 1 Introduction

During the last decade, digital technologies have become an integral part of society and social change. Digital technologies play both a part in shaping and shaped by social activities, organisational behaviour, and individuals' daily life. The rapid digitalisation has presented novel value-producing opportunities and promoted prosperity, but it has raised increasing concerns on digital divide and inequalities between those who have access to technology and those who do not (Parsons & Hick, 2008; Robinson et al., 2015).

Research on digital divide has recognised multiple aspects of digital inequality, defined expansively in terms of access, skills, usage, motivation, and self-perceptions (Dijk, 2005; Dodel & Mesch, 2018; Robinson et al., 2015). In addition, recent studies have indicated that several socio-economic factors can affect individual adoption and use of technology, such as income, age, and educational attainment (Riggins & Dewan, 2005). Among these factors, education plays an extremely important role as it does not only improve individual skills to manage technology's complexity but also encourage individuals to use technology in their professional and personal lives (Cruz-Jesus, Vicente, Bacao, & Oliveira, 2016; Rogers, 2003). Nevertheless, as digital technologies have also pervaded different aspects of learning and teaching, educational policymakers and institutions must concern digital inclusion in education (Cruz-Jesus et al., 2016; Hohlfeld, Ritzhaupt, Dawson, & Wilson, 2017). For example, the extensive use of learning management systems and online learning platforms allows for distance learning. Still it creates learning barriers to those who do not access to digital devices and internet. Nevertheless, a search of the literature revealed few studies which systematically examine the intertwined links between these two domains. Accordingly, this study attempts to investigate the relationship between educational technologies and digital inclusion with respect to all facets including accessibility, skills, and motivation.

Contemporary discourses have focused on whether the application of technologies will help either bridge the digital inequalities or further the divide (Buré, 2006; Henwood et al., 2002). The effective use of information and communication technology can significantly contribute to social inclusion (Andrade & Doolin, 2016; Mervyn, Simon, & Allen, 2014), promote learning (Aainsqatsi et al., 2013; Ainley, Enger, & Searle, 2008) and offer better access to essential skills for all social groups (Caswell, Henson, Jensen, & Wiley, 2008; Nguyen, Gardner, & Sheridan, 2018). What is not yet clear is the impact of applying technology in learning and teaching on social inclusion. The question to be asked is whether digital learning encourages closing the gaps towards digital inclusion or becomes encumbered by the digital divide.

In this paper, we investigate the "what" and "how" of digital learning activities related to digital inclusion. Particularly, we address the following research questions: What are the fundamental dimensions for digital inclusion, and How do digital learning activities relate to them? In order to answer these questions, we apply design science research (DSR) paradigm and views the taxonomy as an Information Systems (IS) artefact (Nguyen, Gardner, & Sheridan, 2017; Prat, Comyn-Wattiau, & Akoka, 2015). Specifically, Nickerson, Varshney, and Muntermann (2013)'s taxonomy development methodology in IS to create and evaluate a taxonomy of educational technologies for digital inclusion. The taxonomy comprises three central dimensions: accessibility, digital literacy, and digital acceptance. The proposed taxonomy could be applied to assess the digital inclusion needs related to digital learning activities. That assessment is to promote the design of digital inclusive pedagogies. Hence, the resultant taxonomy is believed to contribute functional, descriptive knowledge related to digital inclusion, technology-enhanced learning, educational information systems and education technology. It is also intended as an aid in understanding the systemic context of digital inclusion.

# 2 Conceptual Background and Related Work

## 2.1 Digital Divide, Digital Literacy, and Digital Inclusion

The unequal adoption of technology is often blamed for establishing and extending a digital divide between those enjoying affordances of technology and others lacking its benefits. Educational technology is also accused of the same responsibility for creating inequalities in education. Today, the education landscape can be considered that of a digital transformation being the engine powering it (Wedlock & Growe, 2017). The adoption, implementation, and use of the affordances offered by the fast-changing technological advancements are necessary. However, it also raises the need to contemplate the digital divide, promote digital literacy and digital inclusion in education.

The digital divide used to refer to "the separation between those who have access to digital information and communications technology (ICT) and those who do not" (Riggins & Dewan, 2005). Beyond the access to ICT, the second level of the digital divide was recognised as the ability to use technology to find, evaluate, use and create digital content. This concept often refers to another term named digital literacy (Jaeger, Bertot, Thompson, Katz, & Decoster, 2012). Currently, the term digital divide is defined as "the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access ICT and to their use of the Internet for a wide variety of activities." ("Digital divide Definition," n.d.)

Similarly, the understanding of digital inclusion in education has gone beyond the notion that inclusion is all about students with special needs (Qvortrup & Qvortrup, 2018). Digital inclusion is now recognised as complex and multi-faceted (Borg & Smith, 2018). Digital inclusion has been generally recognised as the opposite concept to digital divide and enhanced by digital literacy. The cooperation of digital divide and digital literacy determines the state of digital inclusion in society. Figure 1 illustrates the relationship between these concepts of digital divide, digital literacy, and digital inclusion.

Up to now, far too little attention has been paid to establish a semantic network between these concepts. A systematic understanding of how digital divide and digital literacy contribute to digital inclusion is still lacking. Consequently, our study investigates how digital learning activities, as a means for improving digital literacy, cooperate with digital divide factors to impact on digital inclusion.

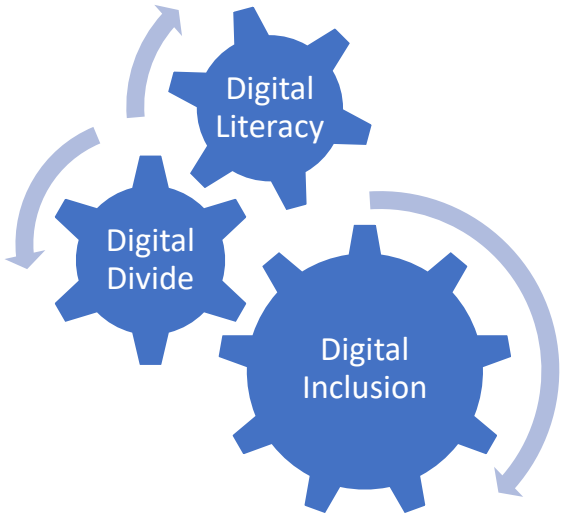


*Figure 1: Digital Divide, Digital Literacy, and Digital Inclusion*

## 2.2 Digital Learning Activities

Learning is the acquisition and modification of knowledge or skills through interaction with reality. The learning process may involve synthesising of various information from different sources. Kolb (1976) suggests that learning is one of the central tasks for all human beings. Likewise, Wang (2016) states that "life is a learning process" and "the most important part of this process is the learning experience from the actual journey". In fact, the learning process is an individual-based activity that the learner can learn only from individual experiences. As a result, personal knowledge is the result of one's personal involvement via the learning process and individual knowledge cannot be detached from the person. Bloom's Taxonomy classified learning objectives into layers of complication and specificity in the three central domains, namely cognitive (knowledge-based), affective (emotive-based) and psychomotor domain (action-based) (Anderson & Sosniak, 1994; Bloom, 1956). The first volume of Bloom's taxonomy focused on cognitive knowledge and knowledge acquisition which are the central points of learning in higher education (Bloom, 1956). Bloom's knowledge-based taxonomy of learning objectives with the highest levels consisting of applying, analysing, synthesising, and evaluating.

Although Bloom's taxonomy was useful in improving communication between educators on the design of curriculum, many studies have criticised this taxonomy for being improperly constructed without a systemic justification(Anderson & Sosniak, 1994). Anderson, Krathwohl, and Bloom (2001) proposed a revised edition of Bloom's taxonomy with the top levels modified to remember, understand, apply, analyse, evaluate and create. The revised taxonomy categorised the lowest order thinking skills as remembering in which learner only obtains and stores new cognitive knowledge. The next level is to understand the obtained knowledge by skills such as interpreting, summarising and classifying. Applying refers to the use and execution of acquired knowledge. The subsequent group is analysing with the

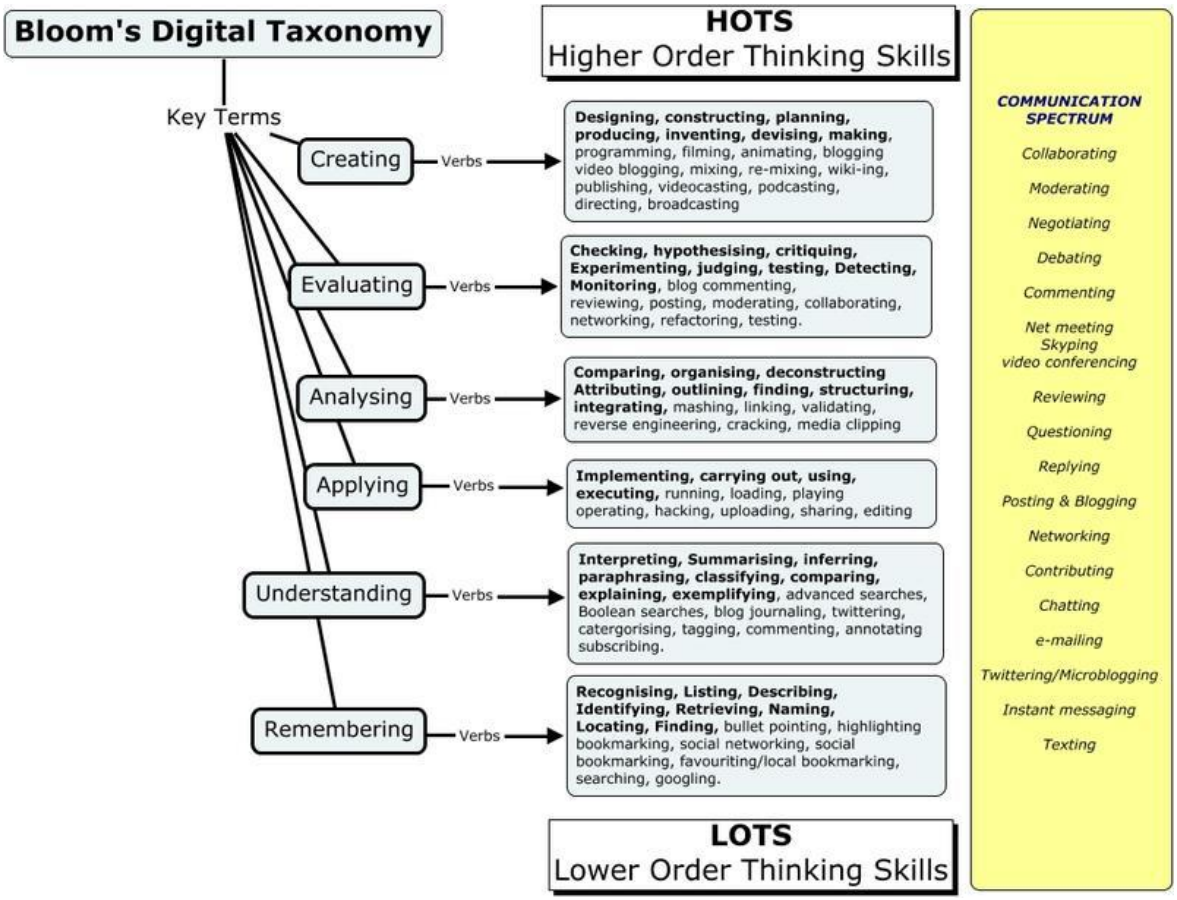


*Figure 2: Bloom's Revised Digital Taxonomy (Churches, 2008)*

skills such as comparing and organising. It is followed by evaluating the learning process with activities like hypothesising, critiquing and monitoring. This revised version of Bloom's taxonomy has been widely spread in education to support the curriculum design. Nevertheless, emerging technologies have changed traditional learning approaches and established new learning activities. For example, the advent of social media has offered learners with the ease of online communication and thus have enabled social learning. Furthermore, the development of learning management systems has empowered online activities such as watching lecture recording, performing quizzes and other assessments, and commenting on learning materials. Taking digital learning objectives into account, Churches (2008) proposed a revision of Boom's Taxonomy for digital activities as shown in Figure 2.

While digital (online) learning is a powerful tool to enhance social inclusion, digital learning activites may not be accessible by all the learners due to the digital divide. We argue that this intertwined relationship plays an important role in leveraging digital inclusion in society, The question to be asked and addressed is that which dimensions of digital inclusions are enhanced by digital learning activites, and which ones hinder them. To answer this, we propose a taxonomy of digital learning activities for digital inclusion to examine the intertwined relationship between them.

### 2.3 Taxonomy in Information Systems

Taxonomy refers to the science of defining and classifying objects of interest based on shared characteristics. A taxonomy can be defined as a scientific classification system with a set of dimensions comprising mutually exclusive and collectively exhaustive characteristics. Notably, in each dimension of taxonomy, each object must have one and only one single value of the characteristics for a specific category. and the characteristics, taken as a whole, must cover the entire category. In addition, the categories can be further grouped together to form hierarchical dimensions. Prat, Comyn-Wattiau, and Akoka (2015)) formulated a taxonomy (T) with hierarchical dimensions ($Dim_i$) of categories ($Cat_{ij}$) and characteristics ($Char_{im}$) of as per the following:

$$T = \{Dim_i, i = 1 \ldots, n | Dim_i = \{Cat_{ij}, j = 1 \ldots, k_i\}|$$

$$Cat_{i1} = \{Char_{im}, m = 1 \ldots, p_i; p_i \geq 2\} \wedge \forall j \geq 2, Cat_{ij} \subsetneq Cat_{i1}\}$$

## 3 Research Methodology

This research aims to construct a taxonomy with critical dimensions and characteristics of digital inclusion. The taxonomy in IS research can be considered as a research artefact in the design science research (DSR) paradigm (Hevner, March, Park, & Ram, 2004; López, Ranasinghe, Patkai, & McFarlane, 2011; Prat et al., 2015). A DSR study involves analysing identified practical problems to formulate research questions, establishing a solution by developing, demonstrating, and evaluating the artefact to demonstrate its efficacy. DSR contributes novel understandings of the application or relevant area to the body of knowledge through the whole design process. In this paper, we examine and design a taxonomy of digital learning activities for digital inclusion to inform the design of inclusive pedagogies.

In doing so, we adopted Nickerson et al.'s (2013) seven-step method for taxonomy development in Information Systems (IS) research (see Figure 3). This method contemplates preceding approaches from different disciplines and extends Bailey (1994)'s classification techniques in social sciences to specify a formal taxonomy development process. In brief, the documented process begins with the determination of meta-characteristics and ending conditions, then proceeds through multiple iterations of constructing and revising dimensions and characteristics, to render an anticipated taxonomy. The objects of interest

are also identified and mapped into the taxonomy during each iteration. The iterative process only ends once both the objective and subjective ending conditions are met.

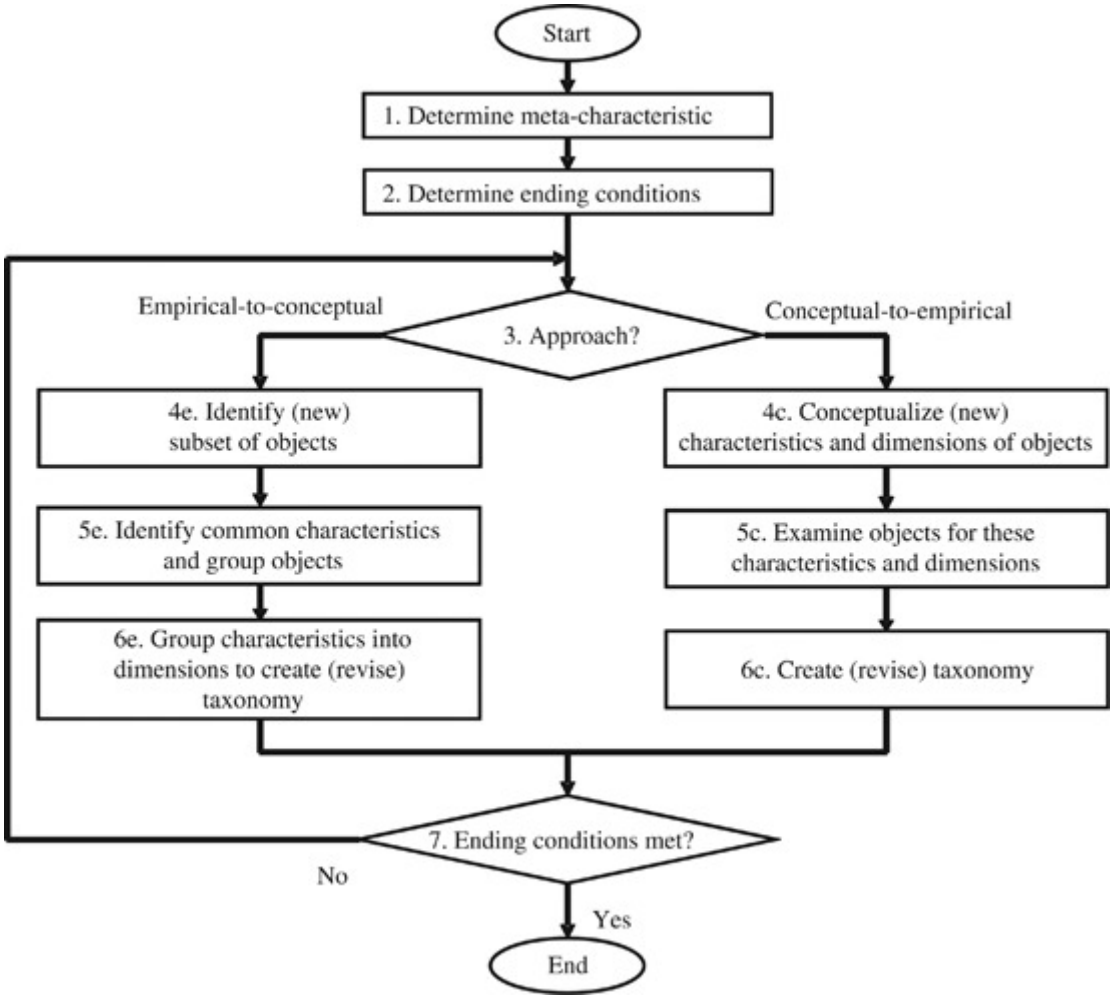


*Figure 3: Method for taxonomy development in information systems by Nickerson et al.'s (2013)*

First, the meta-characteristic, as a crucial component of the taxonomy, is defined to regulate the selection of distinctive characteristics. The meta-characteristic indicates and reflects on the research objectives and the purpose of taxonomy development. After the meta-characteristics are specified, objective and subjective ending conditions are defined for the iterations of taxonomy construction. Each iterative cycle of taxonomy development can follow either conceptual-to-empirical or empirical-to conceptual approaches.

The conceptual-to-empirical approach refers to the process of conceptualising the taxonomy's dimensions at first then determines characteristics for each dimension. Once the dimensions and characteristics are defined, the objects of the taxonomy will be applied to appropriate categories to form or revise the taxonomy. On the other hand, the empirical-to-conceptual approach starts from the identification of actual objects from the real-world then establishes sharing characteristics among each category of objects. In the final step, the characteristics are classified into categories to create or revise the taxonomy. The approach selection depends on the researcher's relevant knowledge and data availability. Several iterations of taxonomy development can occur until when both objective and subjective ending conditions are fulfilled.

In this paper, we adopt the conceptual-to-empirical method to conceptualise the critical dimensions of digital inclusion from the existing literature and government reports. We reviewed papers from several journals and conference proceedings related to information systems and educational technology research with topics related to the digital divide, digital inequalities, digital literacy, and particularly digital inclusion. From the conceptualisation, the dimensions and characteristics of the proposed taxonomy are established and mapped with digital learning activities. The digital learning activities were identified and sampled from Churches (2008). Our approach for literature search follows the process of formulating the search terms documented by Wen, Li, Lin, Hu, & Huang (2012), whereas our strategy for developing taxonomy in IS research follows previous studies published in the Association of Information Systems (AIS)'s conferences and journals (Jöhnk, Röglinger, Thimmel, & Urbach, 2017; Nguyen et al., 2017; Prat et al., 2015).

The evaluation of the initial taxonomy leads to the second iteration which adopted the empirical-to-conceptual approach suggested by Nickerson et al.'s (2013). The second iteration revises initial results to validate the comprehensiveness of the taxonomy of digital learning activities for digital inclusion. This iteration also evaluates the ending conditions of the revised taxonomy.

# 4 Taxonomy Development

## 4.1 Meta-Characteristics and Ending Conditions

We define the meta-characteristics based on the formulated research questions to reflect the goal of the taxonomy. Accordingly, the meta-characteristics are: "What" are critical dimensions for digital inclusion and "how" they are related to digital learning activities so that they can be applied to create inclusive pedagogies.

The objective and subjective ending conditions are also defined for the iterative development process of this taxonomy. We applied Nickerson et al. (2013) ending conditions and outlined ending conditions applied in the development of the taxonomy as showed in Table 1.

*Table 1: Ending Conditions for the Development of the Taxonomy*

| | | | |
|---|---|---|---|
| Objective Ending Conditions | The definition of a taxonomy satisfied. | Each dimension consists of mutually exclusive characteristics. | |
| | | Each dimension consists of collectively exhaustive characteristics. | |
| | Generalizability achieved. | All objects of interest or a representative sample of them have been investigated. | |
| | Comprehensive sets of dimensions and characteristics obtained. | Each characteristic of each dimension must include at least one classified object. | |
| | | No changes (new, update, merge, split, or delete) of dimensions or characteristics in the last iteration. | |
| | | Every dimension is unique and within each dimension, every characteristic is unique. | |
| Subjective Ending Conditions | An appropriate number of dimensions and characteristics used to classify all objects of interest. | Concise | A limited number of dimensions and characteristics used. |
| | | Robust | An adequate number of dimensions and characteristics to differentiate among objects. |
| | | Comprehensive | All essential dimensions and characteristics to classify all objects of interest. |

| | | | |
|---|---|---|---|
| | Ease of Use | Extendible | Uncomplicated insertion of new dimensions and new characteristics or additional characteristics of an existing dimension. |
| | | Explanatory | All dimensions and characteristics can offer a useful explanation about every object. |

## 4.2 The conceptualisation of Digital Inclusion

In the initial iteration of the taxonomy development, we adopted the conceptual-to-empirical approach to conceptualise dimensions and characteristics of digital inclusion based on the literature. At first, critical aspects of digital inclusion are identified from the existing research and government reports then the dimensions and characteristics of the taxonomy are conceptualised.

From the literature review, the key aspects of digital inclusion proposed by Dijk (2005) best fit with the purpose of this taxonomy development. These aspects consist of motivational access, material access, skills access, and usage access. Motivational access is principally determined by attitudes toward technology. Material access reflects the opportunity and means to access technology. After embracing a favourable attitude toward technology and acquiring physical access, relevant skills are required to use technology. Accordingly, skills access reflects the acquisition of the necessary skills to utilise technology efficiently and effectively. The actual usage of technology is the final stage of digital access in Dijk (2005)'s model. However, we reasoned that the usage of technology is an outcome and highly dependable on the other three aspects; thus, this aspect does not fit the meta-characteristic of our taxonomy. As a result, the initial set of critical dimensions includes motivation access, material access, and skills access.

We evaluated the initial set of critical dimensions grounded from the literature by comparatively assessing against the government reports. Particularly, we examine the identified key aspects of digital inclusion with those reported by the European Commission and New Zealand Government (as shown in Table 2).

*Table 2: Critical Dimensions of Digital Inclusion*

| Dimensions selected from the literature review: Dijk (2005) | Motivational access | Material access | Skills access | Usage access |
|---|---|---|---|---|
| European Commission ("Digital Inclusion for a better EU society \| Digital Single Market") | Social Inclusion | Accessible ICT | Skills and digital skills | Assistive technologies |
| New Zealand Government | Motivation | Access | Skills | Trust |
| ***Proposed Critical Dimensions of Digital Inclusion*** | ***Digital Acceptance*** | ***Technology Accessibility*** | | ***Digital Literacy*** |

Both European Commission and New Zealand Government recognise the identified dimensions, namely motivation to participate in and benefit from today's growing knowledge and information society, accessibility to technology, and skills to use technology effectively and efficiently. Although the naming and definition vary between the sources, the ontological characteristics of the recognised factors are highly similar.

In addition to the initial set of critical dimensions, the European Commission also recognises assistive technologies as an essential aspect of digital inclusion. However, to some extent, assistive technologies can be classified into material access dimension in which everyone including people with disabilities must have the opportunity and the means to access technology. To better reflect this concept, we redefine this dimension as *Digital Accessibility*.

New Zealand Government's Digital Inclusion Blueprint indicates trust as another key aspect of digital inclusion. Specifically, trust consists of two subdimensions: confidence and understanding. The first subdimension refers to the confidence to do all that they want to do online whereas the second subdimension reflects the understanding of what to do while facing significant challenges, and how to maintain their confidence. Nevertheless, previous studies have documented a strong correlation between trust and attitudes toward digital activities (van der Heijden, Verhagen, & Creemers, 2003; Wu, Zhao, Zhu, Tan, & Zheng, 2011).

To comply with the appropriateness ending conditions, the motivational access dimension is redefined as *Digital Acceptance* which consists of awareness, perceived usefulness, perceived usability, and trust in technology. Nevertheless, as perceived usefulness and perceived usability is highly related to the system design and does not fit the defined meta-characteristics, we exclude these categories from our taxonomy. Furthermore, skill access dimension is renamed as *Digital Literacy* for more consistent naming convention.

To sum up, the critical dimensions of digital inclusion are recognised as *Digital Accessibility, Digital Literacy,* and *Digital Acceptance*. Figure 4 presents a conceptual framework of digital inclusion based on these conceptualised critical dimensions. Hereby, the characteristics of each dimensions are examined to formulate the initial taxonomy.

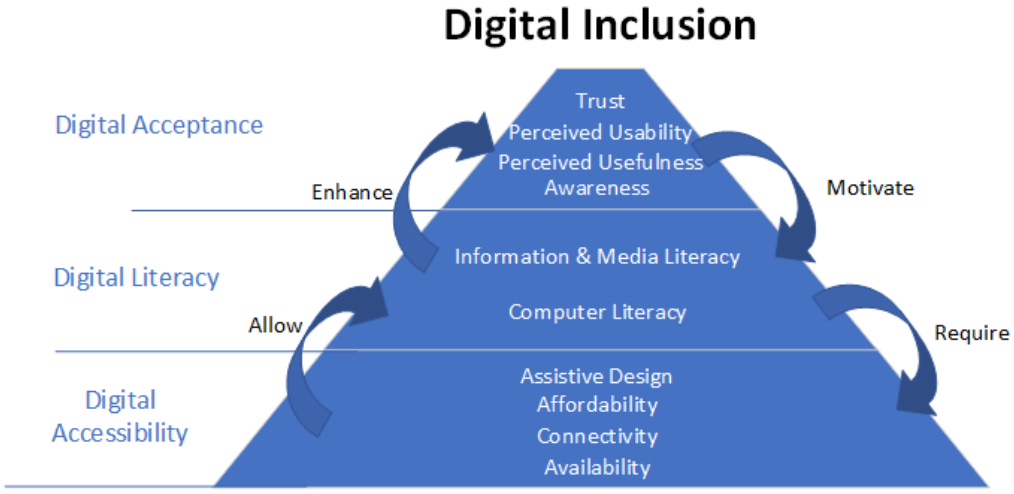


*Figure 4: Conceptual Framework of Digital Inclusion*

### 4.2.1 Digital Accessibility

The first category of accessibility is availability, which refers to the opportunity and means to access specific education technology. In this case, the availability category is used to indicate the technology genre required for the learning activity. Regarding the availability aspect of technologies, we adopted Bruce & Levin (1997)'s taxonomy that views technologies as media for inquiry, communication, construction, and expression. Furthermore, we also add in the "any applications" characteristic for those learning activities that can be generally applied to any software available.

$$AvailabilityRequirement = \left\{ \begin{matrix} Inquiry(InqAR); Communication(ComAR); Construction(ConAR); Expression(ExpAR) \\ Any\ Applications(AnyAR) \end{matrix} \right\};$$

Internet connection is essential for any Information Society as it is required for digital communications and information exchanges (Borg & Smith, 2018; Noll et al., 2018). As a result, the second category of accessibility indicates the connectivity of devices to the Internet. It has three characteristics namely online(onl), offline(off) and either to indicate whether there is a need to get access to the network.

$$Connectivity = \{Online(Onl); Offline(Off); Either\}$$

As the affordability depends on each unique case and its applied products, it is not applicable to a generalised taxonomy of digital learning activities. Therefore, it is excluded from the taxonomy construction to ensure the proposed taxonomy has generalisability.

### 4.2.2 Digital Literacy

Digital literacy can be defined as the ability to find, evaluate, utilise, and create information by using various tools and platforms effectively and efficiently. Digital literacy consists of computer literacy and information and media literacy. While computer literacy focuses on the skills required for using digital devices, information and media literacy refers to the ability to find, evaluate and utilise needed information and media. The definition of information and media literacy and its importance have been recognised by several organisation and governments (Jaeger et al., 2012). Regarding the Digital Literacy category, we have "High; Medium; Low" to present the expertise level required for the learning activities. Whereas the category of information and media (IM) literacy consists of five characteristics: Find, Evaluate, Utilise, and Create. The assumption is that the following characteristics embrace all the previous ones. For instance, the learning activity involves "Create" level of IMLiteracy should also entail the whole process of finding, evaluating, utilising and creating information and media. The rationale is that the performance of the preceding task(s) is crucial for competently performing the following task. We also reasoned that the required levels of digital literacy would also reflect the expected outcomes of the learning activities.

$$DigitalLiteracy = \{ComputerLiteracy\{High(HCL); Medium(MCL); Low(LCL)\};$$
$$IMLiteracy\{Find(FIM); Evaluate(EIM); Utilise(UIM), Create(CIM)\}\}$$

### 4.2.3 Digital Acceptance

Digital acceptance refers to the understanding and attitudes towards the use of digital technology. This dimension contains the awareness of technology, perceived usefulness, perceived usability, and perceived trustworthiness. However, as reasoned above, the perceived usefulness and usability are excluded from endorsing the generalisability of the taxonomy. Furthermore, the awareness of technology significantly relates to the perceived trustworthiness (Wu et al., 2011). As a result, these dimensions only contain two main categories related to awareness and trust: security and privacy. The first category reflects on the ability to understand and enhance the system security whereas the second one refers to one's awareness and literacy of data privacy.

$$DigitalAcceptance$$
$$= \{Security\{SecurityAware(AS); SecurityEnhance(ES); NotRelated(NS)\};$$
$$IMLiteracy\{PrivacyAware(SP); PrivacyEnhance(EIM), NotRelated(NP)\}\}$$

## 4.3 Identification of Digital Learning Activities for Digital Inclusion

The objects for digital learning activities was sampled from Bloom's revised digital taxonomy by Churches (2008) (step 5c). The taxonomy of digital learning activities for digital inclusion is created and demonstrated in Table 3:

*Table 3: Digital Learning Activities for Digital Inclusion*

| Digital Learning Activities | Accessibility | | Digital Literacy | | Digital Acceptance | |
|---|---|---|---|---|---|---|
| | Availability | Connectivity | Technology Literacy | Info. & Media Literacy | Security | Privacy |
| *Bullet Pointing* | ComAR | Off | LCL | EIM | NS | NP |
| *Highlighting* | ComAR | Off | LCL | EIM | NS | NP |
| *Boolean searches* | InqAR | Either | LCL | FIM | NS | NP |
| *Running* | AnyAR | Either | LCL | FIM | NS | NP |
| *Loading* | AnyAR | Either | LCL | FIM | NS | NP |
| *Hacking* | ConAR | Either | HCL | UIM | ES | EP |
| *Reverse Engineering* | ConAR | Either | HCL | CIM | ES | EP |
| *Blog commenting* | ComAR | Onl | LCL | CIM | NA | AP |
| *Programming* | ConAR | Off | HCL | CIM | AS | AP |
| *Filming* | ExpAR | Off | MCL | CIM | NA | AP |
| *Broadcasting* | ComAR | Onl | MCL | UIM | NA | AP |

# 5 Evaluation of the Proposed Taxonomy

For the empirical-to-conceptual evaluation, new digital learning activities were plotted into the proposed taxonomy and the results are illustrated in Table 4. As there were no new dimensions and attributes identified in the empirical-to-conceptual, the ending conditions were checked for terminating the taxonomy development loop. All the objective and subjective ending conditions were met, hence the taxonomy of digital learning activities for digital inclusion is proposed as the result of this study.

*Table 4: Taxonomy of Digital Learning Activities for Digital Inclusion*

| Digital Learning Activities | Accessibility | | Digital Literacy | | Digital Acceptance | |
|---|---|---|---|---|---|---|
| | Availability | Connectivity | Technology Literacy | Info. & Media Literacy | Security | Privacy |
| *Networking* | ComAR | Onl | MCL | UIM | AS | AP |
| *Wiki-ing* | InqAR | Onl | MCL | FIM | NA | AP |
| *Video Casting* | ComAR | Either | MCL | UIM | NA | AP |
| *Pod Casting* | ComAR | Either | MCL | UIM | NA | AP |
| *Publishing* | ComAR | Onl | MCL | CIM | NA | AP |
| *Annotating* | ConAR | Either | LCL | CIM | NA | AP |
| *Group networking* | ComAR | Onl | MCL | UIM | NA | AP |
| *Searching* | InqAR | Either | LCL | FIM | NA | AP |

# 6 Discussion and Conclusions

Considering the increasing importance of digital inclusion as a key growth strategy for the digital transformation of society, this study examined and conceptualised its critical dimensions. Particularly, we explored the digital inclusion related to digital learning activities through the development of a taxonomy following Nickerson et al.'s (2013) methodology. Our taxonomy comprises three central dimensions of digital inclusion that help to indicate digital needs and potential digital divides when planning learning activities. These dimensions are: Digital accessibility (opportunity and means to access technology), digital literacy (ability to use technology to find, evaluate, utilise, and create information effectively and efficiently), and digital acceptance (the understanding and attitudes including trusts towards the use of digital technology).

We have also proposed Conceptual Framework of Digital Inclusion from the theory-inspired conceptualisation of digital inclusion. Our study hopes to provide a better understanding of digital inclusion and its critical dimensions. Teachers could apply our proposed taxonomy for assessing digital inclusive needs while planning learning activities. The taxonomy will act as a tool for teachers to map in resources required for their learning design. Accordingly, they can establish a more inclusive curriculum for students from different backgrounds.

Furthermore, the assessment using our taxonomy could indicate digital literacy as learning outcomes of digital learning activities. By using the taxonomy in designing the assessment, teachers can expect specific enhancements to students' skills that allow them for utilising digital technology. As a result, teachers could encourage those activities with the least requirements and the most influences on digital inclusion.

The proposed taxonomy could also aid the educational policymakers in strategic planning for digital inclusion at institutional and national levels by aggregating the digital inclusion needs from digital learning activities. Hence, they can identify and improve the basic needs for leveraging digital inclusion in society. For example, as most learning activites benefit from internet connection, the investment on the network infrastructure will greatly enhance digital inclusion both directly and indirectly via digital learning activities for digital inclusion. Lastly, this study has presented a semantic and systematic view of digital inclusion in the hope to establish a foundation for further development and implementation of a pedagogic approach to digital inclusion.

The proposed taxonomy is subject to certain limitations that stimulate further research. First, the definition of digital inclusion categories and their characters could be re-evaluated with further empirical-to-conceptual iteration to consolidate the rigorousness of the taxonomy. Second, as the educational context is complex and changing over time, further research is required to validate the efficacy of the taxonomy and to refine it. Whilst this study acknowledges the limitations and suggests future research directions, it partially substantiates the importance and usefulness of a taxonomy of digital learning activities for digital inclusion.

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