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Jukka Jouhki
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Contents

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From the Editor in Chief

THE AXES OF THE MODERN AGE

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This issue of *Human Technology* is essentially about adapting to new technologies. The adaptation phenomenon presents an ever-intriguing, constant process of human history. Innovations increase efficiency and evoke enthusiasm but also cause frictions, tensions, and even dramatic ruptures when the prestige of the old technology is challenged by the lure of novelty.

Recently, an interesting tweet appeared on *Human Technology*'s feed. The tweet addressed an old, prestigious, and society-transforming technology: the book. A Finnish journalist posted a humorous question concerning her reading hobby: "Has my reading gotten out of hand if I take a book even to sauna?"[1] At this point, readers not familiar with the Finnish society would benefit in knowing that Finns are members of a sauna-loving nation (most apartments have a private sauna). Equally, they are avid readers, measured by the daily time spent reading (Brown, 2018).

The ensuing discussion on the Twitter thread was jolly and humorous, but it reflected nonetheless the adoration for, powerful position of, and staying power of this particular form of technology. Even though the initial tweet was meant to amuse the audience, I do not doubt the journalist actually had contemplated the idea or even actualized it, and had indeed read a book in the hot and steamy sauna room. It seems she even took some pride in the act. So did her followers, and one of them wondered whether it was even possible to read so much that it got "out of hand." Indeed, book reading is respected to the extent that one can hardly "go too far," and the sense one could derive from the responding collective is that it does not matter what kind of a book the person is reading, just as long as they are reading one. In this sense, the medium *is* the message, as Marshall McLuhan claimed (McLuhan, 1964)**.**

If this feels a bit like overanalyzing, imagine a tweet similar to the one above but where *reading* was replaced with *social media use* and *book* with *mobile phone*. The question then would have been, "Has my social media use gotten out of hand if I take my phone even to sauna?" I suspect that the tone of the thread to this latter question would have been different. Reassuring comments would have been rare, regardless of the type of content the user was enjoying on social media.

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Yet, both the book and the smart phone are simply communication technologies, and using either one usually involves some measure of reading; however, the former is more prestigious as a medium than the latter. The book holds a long tradition during which it has been established as a symbol of sophistication, knowledge—and even power. The smart phone and social media are more recent, easier, multifunctional, and less established, and thus they often are exposed to moral concern. Although one can learn and develop one's thought and skills, including literacy, by using a smart phone (e.g., West, 2014), its position within the societal hierarchy is lower than that of the book, and thus one of the reasons why people worry more about screen time than about book time. Indeed some parents—in their goal of parenting well—seek to replace their children's screen time explicitly with book time, and there is plenty of research to support their concerns.

However, it is only rarely discussed how even book time can sometimes be harmful intellectually, socially, psychologically, and even physiologically (see, e.g., Dali, 2014; Gerdes, 2015; Short, 2019). For a classic example, one can peruse the century-old diary of the famous anthropologist Bronislaw Malinowski and discover how his excessive reading habit was constantly in the way of conducting ethnographic research among the people he was supposed to study (Malinowski, 1967/1989). If worrying about excessive book time sounds strange or funny, it might be partly because of its traditional position in one's society.

At this point, I, as an anthropologist, am reminded of a classical study of technology, titled "Steel Axes for Stone-Age Australians," by J. Lauriston Sharp (1952), who vividly described how stone axes were the prestigious symbol of the older male elite among an Australian aboriginal group. The Yir Yoront were a Paleolithic hunter-gatherer society who inhabited the west coast of the Cape York Peninsula in modern-day Queensland. For a long time, the stone ax played an important role in the Yir Yoront economy and culture, because not only was it a central, essential tool in use, but also for the interrelated reasons that it was the center of elaborate rituals and a medium of partnerships among communities. Even clan names were derived from the stone ax, and the stories of mythical ancestors revolved around axes. However, only the older men owned an ax, held it in ceremonies, or pantomimed its use in ritual performances. Although women and younger men could use the ax in everyday contexts, and often did so even more than the older men, they always had to borrow it from the older men who were the only ones who could declare ownership of the ax. It was thus an important symbol of hegemonic masculinity.

With the influx of European settlers to Australia, steel axes became available to the aboriginal communities. The settlers were eager to sell the axes to the aboriginals, give them in lieu of salary, or even distribute them freely for charitable purposes, hoping that the tool would allow the aboriginals to improve their lives. However, most older males of Yir Yoront rejected the steel ax as a vulgar and unfit foreign object even though it was clearly a superior tool—more durable, efficient, and comfortable to use as compared to the old stone ax. The widely available steel ax was a threat to the symbolic power of the stone ax, and hence older male power.

However, the women and young men of the community, finding immense benefits in the steel ax, were quick to adopt it. Slowly, the adopted steel ax began to undermine the traditional power of the older males. In time, the stone axes started to vanish from the center stage of male-lead ceremonies; indeed, the existence of steel axes chipped away the significance of the ceremonies themselves. The older men were not happy about their diminishing control over the resource gathering of the young men and the women. They also were ashamed of having to borrow a steel ax from their inferiors. As a result, with the introduction of the steel ax, the old conceptions about gender and age began to change. The charitable settlers where not happy either because they had hoped that the steel ax would help the aboriginals to complete building the settlers' choirs faster so that the workers could spend more time on other tasks. Instead, the aboriginals spent the newfound time resting.

One could say that social media—and any other significant technological innovation about to supersede an older one—propose the same kind of sociocultural challenge to modern society as the steel ax did to the Yir Yoront. Although social media are not challenging the hegemony of older males, at least not as on the same scale as the steel ax did in Australia, they are changing social dynamics in practice. Information, worldviews, opinions, and ideologies spread via social media faster and more effectively than the same information in a printed book. People who previously did not have a voice and the accompanying social influence now can experience what they might deem as equality, and sometimes they are not the kind of people who identify with the learned society–or vice versa. Thus, the literati may have many reasons to worry about the fate of the book, and some of them seem to revolve around the "ownership" of the technology. Throughout history, the book that is "owned" by the educated classes is impossible to overuse, whereas the smart phone–even though it also is used for reading–is viewed as easily overused and abused, especially by the young and the uneducated. Certainly well-documented research can be found easily on the dangers of excessive screen time in general and social media in particular (e.g., Hutton, Dudley, & Horowitz-Kraus, 2019; Nelson, 2018; Soumya & Revathy, 2018). But it is possible as well that the narratives about the dangers of the social media and the superiority of the book are bolstered by worries about the diminishing hegemony of the literati. The proponents of the old technology want to safeguard their old textual realm and the related ideas of "proper" reading and writing.

Thus, social media (like the steel ax of the Yir Yoront) is changing power structures, and it is either welcomed or frowned upon. It has good or bad consequences, depending on one's sociopolitical outlook, but also reflects the differing symbolic value given to it. The book and the smart phone can surely coexist peacefully, but perhaps it could happen more easily if the technologies were not seen as having different intrinsic values. They are both media, and the use and value of them is determined by humans who use (or refuse) them, and both can be used for good and bad.

The technological change, and the negotiations it brings about, do not seem quite as dramatic in the articles of this issue as they were among the Yir Yoront or even in the recurring discussions about the role of social media. Nevertheless, interesting frictions, signs of cultural change, and fluctuating power positions are evident in them. In the article titled "Measuring Expectation for An Affordance Gap on a Smartphone User Interface and Its Usage Among Older Adults" by **Chui Yin Wong, Rahimah Ibrahim, Tengku Aizan Hamid,** and **Evi Indriasari Mansor**, the authors present evidence in how age matters when looking at the affordances of mobile phones. Perhaps a bit like the Yir Yoront older males, the older adults in Wong et al.'s study are confronted with a superior means of communicating—a smart phone—but struggle with the implications of using a smartphone interface that does not easily fit with their mental models of interaction. This new technology also impacts the dynamics of social relations because the older users must rely on their younger relatives in managing the unfamiliar tool. Further, in the article titled “Utilizing Digital Tools to Support Face-to-Face Care: Examining Uptake Within the Practices of Australian Psychologists,” based on a pilot study, authors **Jeremy Kerr** and **Ashley Van Houten** explored therapists’ current adoption of digital tools within and beyond the traditional therapy sessions. Their study discusses how technologies could extend face-to-face care but also the implications of technologies—including social media—to the how, when, and where of psychological care. The study’s findings seem to suggest that the therapeutic culture is “organic” enough to be relatively slow in adapting digital technologies, even when some therapists are generally tech savvy. **Andreja Istenič Starčič and Maja Lebeničnik**, in their article “Investigation of University Students’ Perceptions of their Educators as Role Models and Designers of Digitalized Curricula,” investigated the younger generation’s view on technology integration in higher education, that is, the students are evaluating their teachers as adopters of educational technology and as role models for technology integration for professional development. According to this pilot study, teachers in some academic disciplines currently are not seen as leaders in new technology use, and this is especially true for students in the education field, who will be teaching future generations raised as digital natives. Finally, in returning to the value of reading, the final article of this issue presents a study of GraphoLearn/GraphoGame,[2] a game to develop reading skills. **Elisabeth Borleffs, Frans Zwarts, Ade R. Siregar**, and **Ben A. M. Maassen** exhibited the results of their study on Indonesian first-graders playing GraphoLearn in their article titled “GraphoLearn SI: Digital Learning Support for Reading Difficulties in a Transparent Orthography.” The article serves as a reminder of the value of games in learning important skills and how new technology can be used to support mastery of an old “technology” that is far from becoming extinct.

ENDNOTES

1. The tweets cited here appeared originally in Finnish and have been translated by the author.
2. GraphoLearn is the research/not-for-profit version of the commercial product GraphoGame.

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MEASURING EXPECTATION FOR AN AFFORDANCE GAP ON A SMARTPHONE USER INTERFACE AND ITS USAGE AMONG OLDER ADULTS

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Abstract: *The smartphone has become a ubiquitous mobile communication tool that plays a crucial role in the daily lives for Malaysian older adults. However, it is not easy for older adults to learn new interaction modes and adopt the smartphone user interface. In this paper, we aim to examine the affordances of a smartphone user interface and its usage by older adults through the lens of Norman's execution/evaluation action cycle (EEAC) framework. A mobile-user interaction study was administered with four tasks. A paired sample* t*-test was conducted to analyze the affordance gap between different levels of expectation. The results revealed that three tasks (making phone calls, adding contacts, and using WhatsApp) were statistically different; the exception was installing mobile apps. The results underscore the importance of mobile apps designers incorporating older adults' needs and expectations as a means to reduce the affordance gap.*

Keywords: *affordance, expectation, older adults, execution/evaluation action cycle, smartphone user interface.*

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INTRODUCTION

Malaysia will be joining the advanced countries in becoming an aged nation by 2035 (Hamid, 2019; Sinnadurai, 2019). This study indicates that 15%, or 5.6 million people, of the Malaysian population will be aged 60 years and above, with an increase in life expectancy due to better health care and improved standards of living.

Mobile technologies such as smartphones have become necessary tools in most societies. Growing numbers of people also have to adopt and use a mobile phone for communication and functional tasks (mobile apps) these days. Given the widespread, prevalent, and ubiquitous nature of technologies such as smartphone devices and broadband services, these gadgets have penetrated and influenced all walks of life, including those of the older adult cohort. Older adults, aged 60 and above, were not raised in the digital era; however, they now represent a market of potential smartphone consumers. A majority of this cohort are more familiar with the feature phones, which are equipped only with basic functions such as voice calling and text messaging (PC Magazine, n.d.; Technopedia, n.d.), rather than the smartphone user interface. However, the birth of the iPhone in 2007 marked the initiation of the "smartphone era" (Anh, 2016; Pothitos, 2016), and 10 years later, almost no one buys a feature phone anymore (Hern, 2017). As a result, older adults cannot escape migrating into the "silver smartphone users" cohort, also known as the "grey market" (Mack, n.d.). Having said this, older adults generally are perceived as "techno-phobic" in taking up new technology (Essén & Östlund, 2011; Fisk, Rogers, Charness, Czaja, & Sharit, 2009; Haederi, 2011; Hogan, 2006, 2009; Nimrod, 2018).

Although the smartphone is becoming a ubiquitous communication tool for older adults in their daily lives, learning the new interactive mode is neither easy nor straightforward for them, and it takes time for them to adopt fully the overall smartphone user interface. As such, affordance plays an important role for interaction and user interface designers in terms of designing and developing an intuitive smartphone user interface. This implies that the concept of affordance is significant for user interface–user experience (UI–UX) designers and mobile app developers when designing an artifact, device, or system in that the UI–UX provides visual cues for users to understand possible actions. Crucially, in the context of this study, the perceived affordance involves both the action possibility and visual appearance for smartphone user interface. Users interact with a smartphone's capabilities through its user interface components, such as icon design and navigation tabs, and they are exposed to several action possibilities. It is essential that all these elements are visibly clear and make sense to the users.

The research question of this study is "What is the affordance gap on levels of expectation for older adults interacting with smartphone user interface?" As such, we aim in this paper to examine the affordance gap by measuring the various levels of expectation (pre- and posttasks) of older adults interacting with smartphone functions and mobile apps. We also explore the reasons for any identified affordance gap in the smartphone user interface among older adults.

PRIOR RESEARCH AND RELATED WORK

This section provides a review of the literature and related work on the affordance concept and its model. In addition, we analyze previous studies on intuitive user interfaces, smartphones, and mobile apps for older adults.

Affordance

The term "affordance" was first introduced by James J. Gibson (1977, 1979), an ecological psychologist with a focus on the field of visual perception. He explained, "Affordances of the environment are what it *offers* to the animal, what it provides or furnishes, either for good or ill" (Gibson, 1979, p. 127, italics in original). Thus, an affordance is a single attribute of an object that allows the user to carry out an action.

In the 1980s, the term affordance was propagated by Donald Norman—a design psychologist situated among industrial designers and the human–computer interaction and design communities—through his *Design of Everyday Things* book (Norman, 1998). He defined affordance as "the perceived and actual properties of the things, primarily those fundamental properties that determine just how the thing could possibly be used" (p. 9). The concept of affordance is applied to the analysis of everyday objects. If the affordance contradicts a user's expectation and mental model of use, the object or artifact most likely will not be used easily and thus may be discarded. Therefore, the user's perception of an object's affordance fosters or jeopardizes usability.

Norman (1998) highlighted that affordance provides strong clues for the operation of things and suggests the range of possibilities. For instance, a chair affords support and, therefore, it affords sitting. In addition, certain types of chair also afford the ability to be carried or to be stackable. Norman distinguished the concept of affordance into two types: actual affordance and perceived affordance. Actual (or real) affordance refers to physical objects available to humans through sight, touch, sound, or to a certain extent, smell or taste of the artifact. For example, a chair allows a user to touch its hardness via its material, for instance, wood or plastic; to view the color of its surface; and to listen to a sound by hitting its surface. On the other hand, in the virtual world, the graphical user interface of a software application represents a perceived affordance. For instance, the user-interface components of a smartphone comprise icons, a menu, navigation tabs, and clickable buttons. Therefore, as an example, a user presses an icon of a phone on the smartphone user interface to make a call. The tactile sensation of touching the phone icon on a graphical user interface is very different from the tactile sensation of pressing a number on or holding a physical telephone.

A vast literature indicates that the appearance of an object, artifact, or system should allow users to know what to do even at the first look. Thus, for a simple design like a button, the users should be able to know to press the button, provided it is "press-able," from its appearance. As a result, a simple design does not require any extra picture, label, or instructions for users to know what action they need to take. Unless the item is a complex design that requires further information from a user manual or training, the user's first impression—or perceived affordance of an artifact or system—will determine whether the artifact is a good or poor design.

In this study, we intended to examine the perceived affordance of a smartphone user interface. The issue for a graphical user-interface component is that it has no obvious physical or real affordances other than what the actual device provides simply as the host for the intended operations of the virtual environment. This difference sometimes poses challenges for users to comprehend how a familiar item works in a virtual environment. Norman (1998) highlighted that users can only learn the perceived affordances of graphical user interface elements in a virtual world (i.e., software programs or mobile applications) through convention. These could be challenging for first-time users who have no visual clues or prior product experience of how to interact with a graphical user interface, in this case, a touch screen interface to the virtual world. This is especially true for adults who start to learn how to use the smartphone user interface in their older years. Thus, no matter what age, users need to learn the convention through practices, or trial and error, several times to become familiar with the use of virtual objects or graphical user interface elements. However, no matter what the services or artifacts, older adults find it useful and interesting to access new media (e.g., photos and videos) on their smartphone, but they also generally find it difficult to navigate through the complex design of a smartphone user interface and mobile applications.

Norman's Execution/Evaluation Action Cycle Model

In a human–computer interaction framework, it is important to understand how older adults interact with an artifact, such as a smartphone user interface, as is the focus of this study. When an object is designed for a purpose (function), it affords interaction between a user and the function itself. Norman (1998) explained the interaction as a way of framing the relationship between people and object by way of the execution/evaluation action cycle (EEAC; Figure 1).

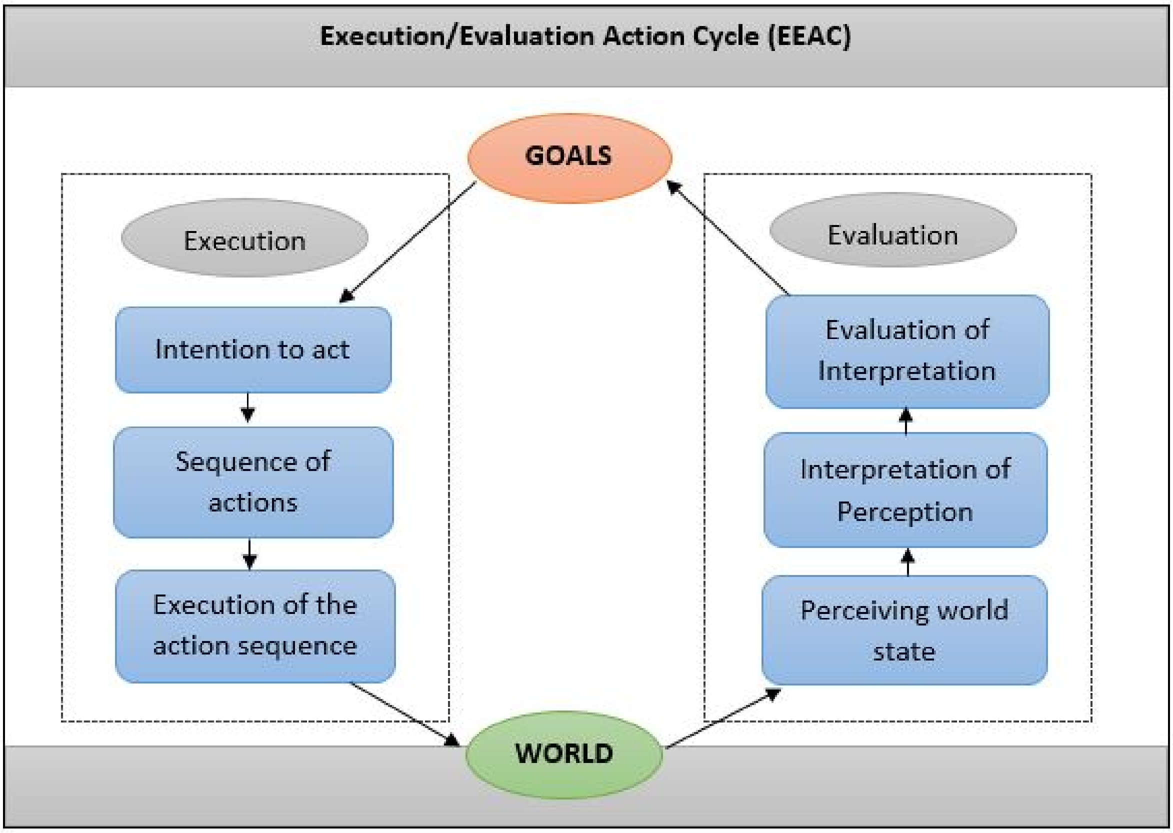

Figure 1. Seven stages of actions under execution and evaluation in the EEAC. The stages of execution begin with the goals, which are then translated into action sequences. This is followed by user's perception of the world that impacts the stages of evaluation (Norman, 1998). The image was adapted by the authors from http://picostart.myweb.hinet.net/

The EEAC model comprises four basic parts: goals, execution, world, and evaluation. A goal is something to be achieved, although often it is stated vaguely. A goal does not specify any particular action. Rather, a goal is an intention for a specific action to be taken to achieve the goal. However, intentions also are not specific enough to control actions. To achieve the goal, then an action in the world must be enacted. Norman (1998) indicated that any action comprises two aspects: execution and evaluation. Execution involves doing something, and evaluation is the comparison of what happened with what was wanted or expected to happen. Yet these are not simple processes. In fact, there are seven stages of actions in the EEAC.

The stages of execution start with a goal, the objective to be achieved. The goal is then translated into an intention to do some action(s). The intention must be translated into a set of internal commands, that is, an action sequence that can be performed to satisfy the intention. The action sequence takes shape as a mental event. Nothing will happen until it is executed, meaning performed upon the world. This is followed by the stages of evaluation, starting with the user's perception of the world. This perception must then be interpreted according to the user's expectations and compared with the intentions and goals. If the system's design and behavior match with the user's expectation and falls within the user's mental model, which is what the user believes about the system at hand (Nielsen, 2010; Norman, 1998), the user will not experience unmet expectations that typically yields frustration and dissatisfaction with the artifact. As such, we intended in this study to examine the level of user expectation before and after a smartphone interaction task. This means we measured how the users perceived an icon design before exposing and interacting with a certain task, and their interpretations of the icon design with its intended function after interacting with the task.

As an example of the EEAC in action, we presented a simple task of how a user interacts with a mobile phone. The goal was to take a phone call; the intention was to answer to an incoming phone call on a smartphone. The action, then, was for the user to react to an incoming phone call on the smartphone user interface. If an older adult is a first-time user of a smartphone, he or she may not understand how to operate a smartphone user interface. For a user whose previous experience was a keypad-enabled feature phone, he or she most likely would attempt to retrieve a phone call by pressing a "phone call" keypad button. However, when migrating to smartphone use, older adults need to relearn the new interaction mode and conventions of how it works. Instead of the former typical interaction mode of pressing, the older adult needs to learn to slide (action) the green colored "receiving call" function in order to pick up the incoming call (intention). Throughout the study observation, we frequently saw first-time users continually pressing the green colored phone icon instead of sliding it, and this led to missed calls and yielded user frustration. As a result, we identified affordance gulfs (gaps) in execution and evaluation, where the perceived function did not match with user expectation. Therefore, in this study, we examined the affordance gaps by measuring the level of expectation of the smartphone user interface by older adults.

Affordance and Its Related Work

The concept of affordance has evolved since its original presentation in the discipline of ecological psychology and, over time, it has been applied across various disciplines, such as design studies, human–computer interaction (HCI) and interaction design fields, media and social media, communication studies, and others. In the HCI discipline, the field in which this study is situated, the concept of affordance has evolved and been developed by various scholars. Gaver (1991) extended the concept of affordance by proposing the technology affordance model, which is applicable for user interface design in HCI studies. The concept of technology affordance focuses on the interaction between technology and the user of it. According to Gaver, affordances are fundamental objects of perception, where people perceive the environment directly in terms of its potential for action, without involving any significant intermediary, such as memory or inference. Under the concept of technology affordance, Gaver described “perceptible affordance" as the perceptual information available for an existing affordance or user interface. This implies that the term perceptible affordance is considered similar to Norman’s (1998) definition of perceived affordance.

In regard to our study, the major scholarship and concepts of the HCI field still are focused on Norman’s (1998) EEAC model. Thus, the concept of affordance that undergirds our study is described broadly as the possibilities for actions between an object/technology interface and the user that enables or constrains potential behavioral outcomes in a particular context (Faraj & Azad, 2012). Hence, the understanding of affordance is accepted universally in this field as “action possibilities offered by the environment” (Kaptelinin, 2013, p. 2565). This concept is more applicable to design and HCI studies and relates to the original notion of Norman’s (1998) EEAC model. Nonetheless, we see a scarcity of research articles that measure the affordance gap. Thus, this study aims to plug a part of that gap in the literature by focusing on measuring the affordance gap in the older adult users’ expectations of the smartphone user interface.

Intuitive User Interface

The design of a user interface refers to the look and feel of software (i.e., mobile apps, software programs) or machines (i.e., mobile devices, computers, home appliances). To ensure the perceived affordance of user interface design is intuitive, Blackler (2006) and O’Brien, Rogers, and Fisk (2007) both highlighted the importance of taking the users’ prior experience and knowledge into consideration when designing artifacts. Prior experience or knowledge is defined as information available in the participant’s memory that is used during the interaction with the artifact. For instance, an older adult’s prior experience using a keypad-enabled mobile phone can help him or her, in some ways, understand some components of a smartphone because of the relatedness between the features of the two phone systems. This is particularly true when compared to someone who has never handled a less complex mobile phone.

To explain further the notion of familiarity, an icon design that depicts a telephone or phone handset is a familiar metaphor suggesting the function of making a phone call in smartphone user interfaces. Norman (1998, p. 62) referred to this information gained from relevant prior experience as “knowledge in the head” (KiH). Meanwhile, other information available to the users—such as instructions, device feedback, mobile-user interface screen controls, and user-interface design components—is considered “knowledge in the world” (KiW). Good design of KiW is important for older adults who prefer to use new technologies with the support of instruction and training. To reduce errors, one design recommendation is to place guidance or external consistency on the display of user interface that links KiW to a user’s prior knowledge (KiH; Norman, 1998; O’Brien, 2010).

If the artifact or user interface of a product is intuitive to use, which means with affordance design, users can call upon their previous experience to complete the task easily without referring to user manuals, receiving help from others, or attending trainings. Thus, a user interface is intuitive when it contains the components of affordance, familiarity, and no frustration to users

(Blackler, 2006; McKay, 2010). Intuitiveness also implies that when UI–UX designers and mobile app developers create smartphone user interfaces and mobile apps, their consideration of affordance and consistency in the design is vital.

To ensure the smartphone user interface is usable and intuitive, various usability evaluation methods are employed in studies to measure the usability and design issues, such as heuristic evaluation, usability testing involving users, focus groups, field observations, and the shadowing method (Gómez, Caballero, & Sevillano, 2014). One popular method of performing usability inspection without requiring too much expertise, time, or expense is the heuristic evaluation (Nielsen, 1994). Nielsen and Molich (1990) designed 10 fundamental usability heuristics for user interface design over a range of system user interfaces. However, some researchers found these heuristic guidelines too general and additional heuristics were developed to cater to specific contexts. For instance, a list of heuristics for smartphone apps targeted toward older adults (Silva, Holden, & Jordan, 2015), heuristic evaluation on mobile interfaces (Gómez et al., 2014), smartphone usability heuristics (Inostroza, Rusu, Roncagliolo, Rusu, & Collazos, 2016), design guidelines and checklists for feature phones and smartphones (Petrovčič, Taipale, Rogelj, & Dolničar, 2018) represent some of context-specific evaluative tools.

Smartphone, Mobile Apps, and Older Adults

Some literature mentioned that older adults have been stereotyped as “late comers” or “laggards” regarding the uptake of new technologies or services (Essén & Östlund, 2011; Price, Pak, Müller, & Stronge, 2013; Wong, 2011). On the contrary, burgeoning research, especially in the fields of HCI, aging, and technology (Abascal & Civit, 2001; Plaza, Martin, Martin, & Medrano, 2011), has been conducted on smartphones and older adults due to the rising aging population worldwide. Other studies revealed that older adults are active smartphone users (Colombo, Aroldi, & Carlo, 2018; Rosales & Fernández-Ardèvol, 2016a; Selwyn, Gorard, Furlong, & Madden, 2003). A majority of older adults, especially those in the young-old cohort, aged 60 to 74 (Fisk et al., 2009), are considered still productive and active at their age, having special information and communication technology (ICT)-related needs, and are interested in learning new technology, including smartphone and mobile apps (Berenguer et al., 2017; Carlsson & Walden, 2015; Nikou, 2015; Rosales & Fernández-Ardèvol, 2016a).

Despite the perception of older adults as late comers to smartphone adoption, a majority of seniors received their first smartphone as a gift or as a second-hand device passed down from a family member (Ivan & Fernández-Ardèvol, 2013; Oreglia & Kaye, 2012; Sun, Ding, Lindtner, Lu, & Gu, 2014). This opens a new era in the mobile business landscape for the telecommunication industry, as well as for mobile apps developers and designers. In contrast, the findings of a survey study conducted in Spain by Rosales and Fernández-Ardèvol (2016a) revealed that a majority (79%) of the older adult respondents bought the smartphone themselves because they wanted a new mobile phone rather than a second-hand device. Family encouragement is the primary factor influencing older adults to overcome their psychological barrier to accepting their first smartphone (Pee, Maksom, & Norizan, 2014; Sun et al., 2014).

In terms of mobile apps usage, another study done by Rosales and Fernández-Ardèvol (2016b) revealed that WhatsApp is the most popular and frequently used mobile application across all age cohorts studied, but especially by older adults (aged 55 to 76 years), in Spain. One reason older adults in Spain were adopting a smartphone was because, with a minimal mobile data plan subscription, it is cheaper to make a WhatsApp phone call rather than using the mobile voice call feature. Interestingly, their findings also revealed that older adults viewed the source of incoming calls differently: Older users felt a sense of urgency in taking calls coming from the voice call function on smartphones whereas a WhatsApp voice call was not deemed an important call. In addition, it seems the older adults were excited to keep themselves active in a WhatsApp group because it allowed them to maintain and reinforce relationship ties with their family members regardless of geographic separation. It also allowed them to share their happenings via media files (photos and videos) with significant others. These findings are supported by research done by Nouwens, Griggio, and Mackay (2017), who found that their respondents used specific mobile apps for specific interactions: WhatsApp to communicate with family members and Facebook Messenger to engage with friends.

Plaza et al. (2011) pointed out that the important reason for older adults to use mobile apps is that they want to live independently in their own homes as long as possible. The needs of older adults using smartphones and mobile apps can be classified into two main domains: “health–wellness–home care” and “safety–security–mobility.” The former domain consists of social interaction, hobbies, information gathering, learning and education, working life, health and wellness, home care, and chores and supply with goods. The latter domain involves issues related to safety-security and privacy, peace of mind, and mobility (Plaza et al., 2011). As such, those young-old adults who are conversant with using smartphones and with ICT use during their active work life will continue to use mobile apps and advanced features on their smartphones after they retire. As a result, domains such as working in later life, spirituality, hobbies, and lifelong learning-related mobile apps are worthwhile for researchers, designers, and developers to explore further.

METHODS

This paper presents part of a larger mobile-user interaction study. This full study was conducted using concurrent embedded design mixed methods (Creswell & Clark, 2011), which means qualitative data (interview) was collected concurrently and embedded within a major quantitative data (survey and observation) collection. The purpose of conducting a concurrent embedded design mixed method was to enhance a better understanding of and to supplement the secondary qualitative data within a larger quantitative study. The quantitative data were analyzed to assess the affordance gap in terms of level of expectation. We used the qualitative data to complement the quantitative data by identifying the reasons for an affordance gap, that is, the mismatch between older adults’ expectations and a smartphone user interface. The qualitative data also aimed to gain insight into how older adult participants interacted with a smartphone UI.

As this is a cross-sectional observational study, it did not include an intervention component. The intention of the study was to examine the perceived affordance on the level of expectation before and after presented tasks and the possible actions taken among the older adults interacting with smartphones.

Participants and Sampling

Due to the nonexistence of national statistical data on the Malaysian older adult population who own smartphones, this study used nonrandom sampling techniques that involved purposive sampling and snowballing. In Roscoe's (1975) rule of thumb, a sample size of 30 or more is recommended in most experimental and observational studies.

We recruited the participants from the attendees at the University of the Third Age (U3A) in Kuala Lumpur, Malaysia. Some also were seniors from community centers in the Malaysian state of Selangor. The U3A offers lifelong learning programs for older adults in Kuala Lumpur and Selangor. We selected this association because it is one of the most active senior citizen organizations in the country. It also offers a first-of-its-kind smartphone-for-seniors training course. In this study, we recruited 80 (40 male and 40 female) older adults as participants for the mobile-user interaction study in 2016. They were aged 60 to 74 years (*M* = 65.63), thus representing the young-old adults cohort.

Two criteria were employed for selecting the participants in this study: the individuals were members of the young-old adults cluster (Fisk et.al. 2009), meaning aged from 60 to 74 years, and each had experience using a smartphone for at least 3 months. This cohort has high potential for actively using online services and mobile apps for the rising "grey market" in the Malaysian mobile industry. Because we focused our study on the operational activities of older adults using smartphones, and not on health-related matters, those who suffered from severe visual, cognitive, motor, and hearing impairment were excluded from participation.

Malaysia is a multiracial society. Thus, all the participants (*N* = 80) were Malaysians, but comprised three major ethnic groups: Malay (27.5%, *n* = 22), Chinese (58.8%, *n* = 47), and Indian/others (13.8%, *n* = 11). The percentage of Chinese older adults was higher among the three groups due to their high "turn-up" rate and that they represented the higher percentage of U3A membership during the 2016 data collection period.

Apparatus and Settings

A smartphone with an Android mobile operating system (OS) served as the test apparatus for this study. An Android smartphone was chosen because the findings from our previous smartphone usage survey (Wong, Ibrahim, Hamid, & Mansor, 2017) revealed that a majority of older adults owned an Android smartphone, and it also was more affordable and popular than the other types of smartphones, the iPhone in particular. In this study, we used a Samsung S7 Edge due to its large 32GB internal memory, allowing us to capture and store screen interaction videos within the phone itself. This model had launched in the global market (March 2016) just prior to our data collection process. The Android 5.0 Lollipop design was the Android mobile OS software version used when we conducted the user testing from May to July 2016.

We conducted the study in a quiet meeting room at the Malaysian Research Institute of Ageing (or Institute of Gerontology), where the U3A is based and many older adults were available. All the participants were scheduled for user testing at a specific time, and each test was conducted independently at U3A.

Task Design

In this study, the four task scenarios were derived from the results of the second phase of the previously completed smartphone usage survey result (Wong et al., 2017), which allowed us to adhere to ecological validity. In short, the four main tasks for this study were making a phone call, adding a contact to a phone book, installing a mobile app using the Google Play Store, and using WhatsApp. Each of these main tasks also contained two or three subtasks in line with goal of the main activity. Table 1 provides the details of the four-task design, details on which can be found in Wong, Ibrahim, Hamid, and Mansor (2018).

Procedure

We received approval from the University Putra Malaysia Research Ethic Committee before conducting the mobile-user interaction study. A screening process was conducted during user recruitment based on the criteria for participant selection. During the mobile-user interaction study, all participants signed an informed consent form; we kept their identities anonymous for data analysis purpose. Each participant was given a code name with number; for example, P1 represents Participant 1. Each session took between 45 and 120 minutes for the users to interact with the given tasks, depending on the participant's ability and familiarity with the smartphone user interface.

Firstly, before we presented the test tasks to the older adults, the participants completed the first part of an affordance questionnaire regarding their demographic profiles, smartphone usage, and their perceived affordance on the level of presumed expectation for selected tasks. They also were interviewed to identify their motivations for and barriers to using a smartphone. This served as the pretest. Next, they were presented the four tasks to perform on the Android smartphone platform. After the participants performed the four tasks, they were asked to complete the second part of the affordance questionnaire, which gathered information on the participants' perceived affordance and experience interacting with the smartphone tasks that formed the quantitative element of the study. Lastly, the participants participated in a follow-up interview during the debriefing session.

The questionnaire was written in three languages: English, Bahasa Malaysia (the national language of Malaysia), and Mandarin. The questionnaire underwent backward and forward translations from English to Bahasa Malaysia/Mandarin and vice versa. All the translations were handled collaboratively among the primary researcher (i.e., the first author), an online translation service company, a certified translator in Bahasa Malaysia and English languages, and a qualified translator in Chinese and English languages. After comparing the forward and

Table 1. Tasks and Subtasks Presented to Young-Old Participants of Concurrent Embedded Design Mixed Methods Study of a Smartphone Interface Affordance Gap.

Task 1: Voice Calls
Subtask 1: Making a call
Subtask 2: Retrieving calls
Task 2: Phonebook
Subtask 1: Adding a contact to a phonebook
Subtask 2: Making a call from phonebook contact
Task 3: Installing a Mobile App
Subtask 1: Go to the Google Play Store to download a flashlight mobile app
Subtask 2: Start initiating the application
Task 4: Using WhatsApp
Subtask 1: Sending a message using WhatsApp
Subtask 2: Sending a photo using WhatsApp
Subtask 3: Sending an audio file using WhatsApp

backward translations, all the meanings remained the same with some variance in sentence structure and grammar. No major correction was done in the translation.

The complete session (from informed consent to debriefing) was video recorded. This process was most useful in gathering intonation and facial expressions during the mobile-user interaction tasks. Additional observation data were collected with Mobizen screen capture software on the Android phone to record the mobile screen interaction. The primary researcher also recorded the timing and verbal comments from each observation sessions. This researcher (mainly the first author) is conversant in the three main local languages, those used for the questionnaire. Hence, each session was conducted in whichever language was preferred by the participant in response to the researcher's inquiry at the start of the session.

Questionnaire and Measures

In this study, the type of measure is self-report. To examine the perceived affordance and possible actions of smartphone user interface among the older adults, the participants were prompted regarding the level of expectation measures before and after interacting with each task. The expectations were measured using a 7-point Likert scale, where 1 indicated *very difficult* and 7 *very easy*. Before every task, participants were asked, "How difficult or easy do you expect this task to be?" Then, after completing each task, they were asked "How difficult or easy did you find this task to be."

Interviews

An interview was conducted before and after the four tasks process. The purpose of interview before the task interaction was to uncover the motivations and rationales that led to the participants adopting their smartphone. During the posttask debriefing session, the interview aimed to discover the participants' opinions of using smartphone and to obtain feedback on their experiences and perceptions while interacting with the four tasks.

Methods of Analysis

The quantitative data were analyzed using a statistical analysis software (IBM SPSS Version 23). A paired sample *t*-test was conducted to examine the affordance gap for expectation levels (pre- and postmeasurement) of perceived affordance on smartphone user interface. On the other hand, we conducted qualitative analysis using NVivo 12 Plus from the observation field notes and interviews. The interviews were coded and organized into categories using thematic analysis (Bernard & Ryan, 2010; Silverman, 2011; Taylor-Powell & Renner, 2003). The categories or themes were then presented with some verbatim quotes as evidence. The qualitative data complement the quantitative data analysis.

RESULTS

This section illustrates and discusses the results of the study in two parts. First, participants' demographic profiles and smartphone usage are presented, followed by their perceived affordance on levels of expectation. These primarily quantitative data results are supported by the qualitative data derived from the interviews following completion of each task and the debriefing.

Participants' Demographic Profiles and Smartphone Usage

In this section, we explain the descriptive statistics for the participants' demographic profiles. Eighty older adults, aged 60–74 years (40 males and 40 females, with an average of 65.65 years), were recruited for this mobile-user interaction study. All respondents were Malaysians. Table 2 illustrates the participants' demographic profiles.

The participants were asked the duration of owning their current smartphone and its brand. The responses show that the average duration was nearly 23 months. The data showed that the older adults would consider changing or upgrading to another smartphone either by receiving a used mobile from their children/family or by purchasing a new phone. A majority (82.7%) owned an Android OS phone, as compared to an Apple or Windows smartphone.

Regarding who purchased the smartphones that the informants currently use, respondents indicated that their children (45%) were the primary source, followed by themselves (32.5%), and others (22.5%), such as spouse, son or daughter-in-law, relative, or friend. This suggests that the older adults in this study considered their children as reliable and more techno-savvy resources to choose and purchase smartphones for them. In terms of a mobile subscription plan, two thirds of the participants (75%) opted for a postpaid as compared to a prepaid service. Finally, 68.8% participants had their data plan or Internet service as part of a mobile subscription plan, as compared to those with no Internet subscription (30%) or who had "no idea" (1.3%).

Regarding the problems the participants experienced when using their mobile phones, the data depicted that the older adults thought that the battery discharged very quickly (58.2%) for a smartphone as compared to their prior experience of using a keypad-enabled phone. Another problem was that 43% of the older adults thought that their "fat fingers" caused problems using the small virtual keypad on their smartphones. Other problems (46.8%) that the participants encountered included the phones easily disconnecting a call, especially when using WhatsApp; becoming baffled regarding notifications on the phone without knowing what to do; the fear of getting virus; and the fear of downloading software upgrades/updates. Based on their children's advice, some older adults feared using features and phone icons that were not familiar; other older uses found the phones complicated to use.

Figure 2 illustrates the purposes for which the older adults adopted and use mobile phones. The results justify our decision for investigating three of the main tasks for the mobile-user interaction study, that is, making phone calls, adding a contact to their device's phone book, and using WhatsApp. The difference of a feature phone as compared to a smartphone is the latter allows the user to download a mobile app and use it on the device. Thus, we also incorporated installing an app from the Google Play Store as an important task to determine whether the older adults know how to download a mobile app, a crucial skill in smartphone use, by themselves.

Perceived Affordance on Expectation

To identify the affordance gap in the level of expectation by the older adults regarding their perceiving (pretest) and experiencing (posttest) smartphone use via the four tasks, we conducted a paired sample *t*-test. At first, to check whether the assumptions were met for choosing either a

Table 2. Demographic Profiles and Smartphone Usage of Malaysian Adults, Aged 64–75 (N = 80).

Descriptions	Percent (%)	Number (*n*)
Gender		
Male	50.0	40
Female	50.0	40
Ethnicity		
Malay	27.5	22
Chinese	58.7	47
Indians and others*	13.8	11
Marital Status		
Single	7.5	6
Married	80.0	64
Divorced, Separated, or Widowed	12.5	10
Educational Background		
Primary and lower-secondary education	10.0	8
Upper-secondary education	40.0	32
Tertiary education (college/ university)	50.0	40
Occupation		
Working	11.3	9
Retired	77.5	62
Never worked	11.2	9
Proficiency in Languages**		
Bahasa Malaysia		
Speaking	91.3	73
Writing	85.0	68
Reading	88.8	71
English		
Speaking	96.3	77
Writing	95.0	76
Reading	96.3	77
Mandarin		
Speaking	42.5	34
Writing	23.8	19
Reading	26.3	21
Tamil		
Speaking	12.5	10
Writing	10.0	8
Reading	11.3	9
Others (e.g., Cantonese, Hokkien, etc.)		
Speaking	27.5	22
Writing	11.3	9
Reading	8.8	7
Monthly Income***		
RM5000 (US$1193.22) and above	11.2	9
RM3000 (US$715.95) to RM4999 (US$1192.99)	23.8	19
Less than RM2999 (US$715.70)	26.3	21
Currently no income	38.7	31
Current Smartphone OS		
Android	82.5	66
Apple iPhone	15.0	12
Microsoft Windows	2.5	2
Problems in Using Mobile Phones		
Complicated and difficult	36.7	29
Expensive	27.8	22
Small keypad	43.0	34
Danger to health	32.9	26
Battery loses charge quickly	58.2	46
Other problems	46.8	37
None of the above problems	7.6	6

Note. *Indian/Others means Indian and other minority ethnic groups in Malaysia. **All the participants (100%) are bilingual. ***The currency conversion is Ringgit Malaysia/RM1 = US$0.24 on June 5, 2019.

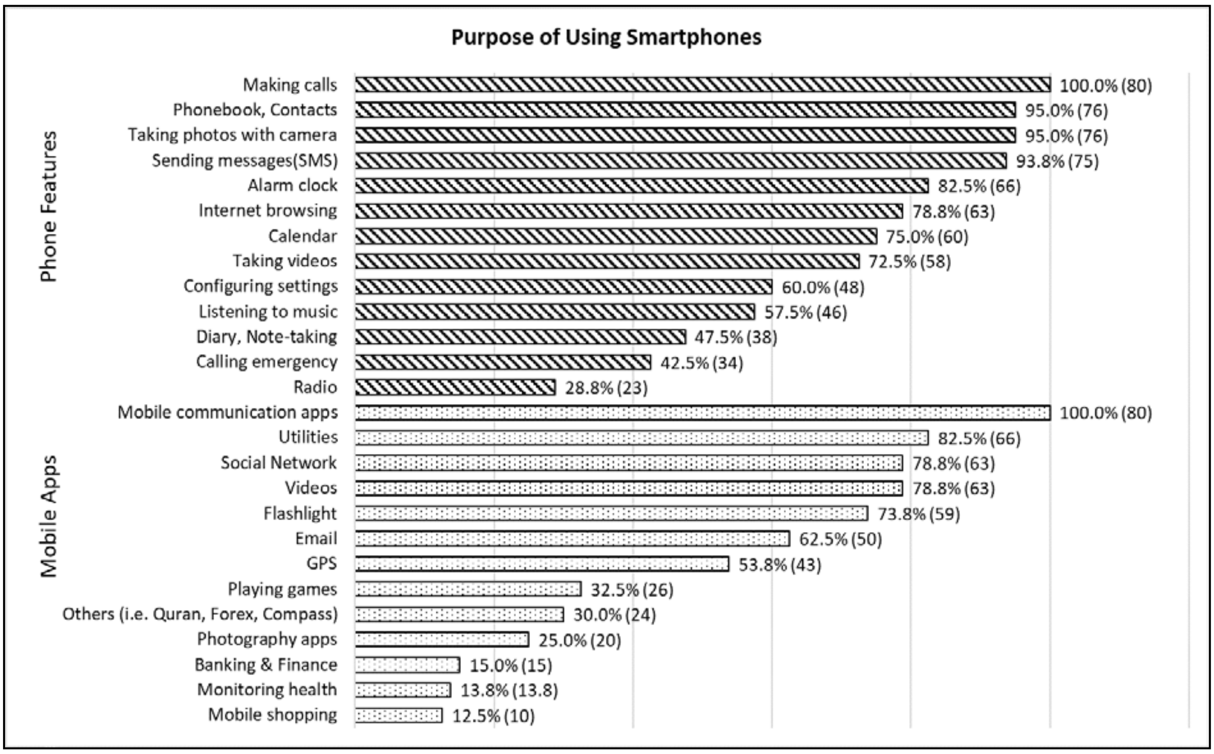

Figure 2. Older adult-identified purposes for using smartphones. Responses are grouped as either phone features or mobile apps.

parametric or nonparametric test, we conducted a normality test, and the results show that all data were normally distributed based on the histogram. Figure 3 depicts the average scores for pre- and posttests of all four tasks. All the tasks showed the average scores above 5.0 except Task 3, installing an app from the Google Play Store.

Table 3 shows the paired sample *t*-test statistical result for perceived affordance on different levels of expectation for the four tasks. The table reveals the mean difference, standard deviation, standard error mean, 95% confidence interval, *t*-score, degree of freedom (*df*) and its significance (2-tailed).

The mean result in Table 3 shows the difference between the two sets of perceived affordance on the level of expectation scores, which was unlikely to occur by chance. However, it does not inform the magnitude of the task effect. As such, we calculated the effect size based on the eta-squared value. To further analyze the magnitude of the effect size for Pair 1, 2, and 4, we referred to Cohen's guideline (Cohen, 1988) for interpreting the Cohen's *d* values, where less than 0.2 = small effect, 0.3 – 0.7 = medium effect, 0.8 and above = large effect.

For Task 1 (making a phone call), the result shows that there is a statistically significant decrease for the older adults making phone call scores from premeasurement (M = 6.26, SD = 1.028) to postmeasurement (M = 5.44, SD = 1.533), $t(79)$=3.764, p < 0.001 (two-tailed), d = 0.62. The mean decrease in using a phone call score was 0.825, with a 95% confidence interval ranging from 0.389–1.261. The effect size is medium. For Task 2 (adding a contact), the result shows that there is a statistically significant decrease for the older adults adding contact scores from premeasurement (M = 5.85, SD = 1.370) to postmeasurement (M = 5.06, SD = 1.781), $t(79)$ =3.693, p < 0.001 (two-tailed), d = 0.50. The mean decrease in adding contact scores was 0.788, with a 95% confidence interval ranging from 0.363–1.212. The effect size is medium.

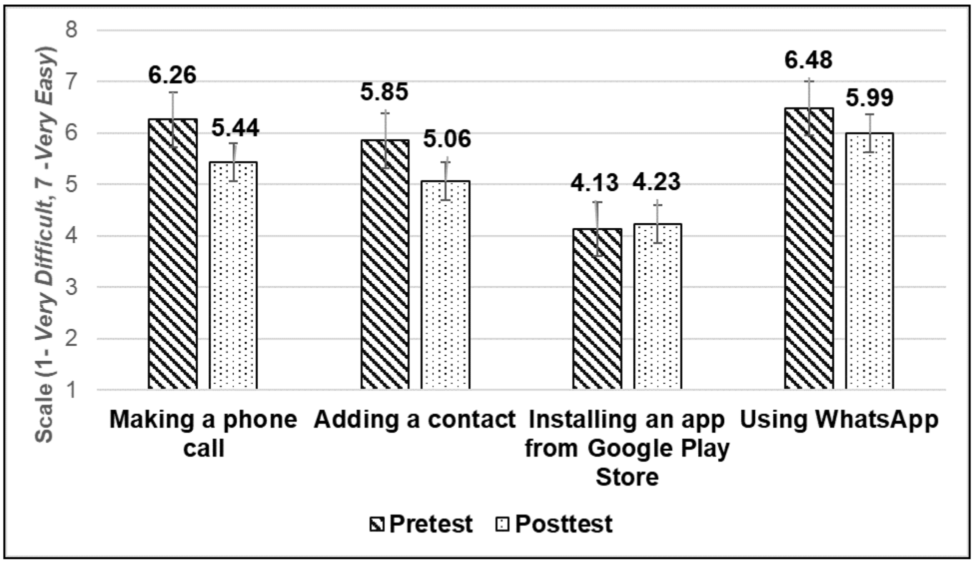

Figure 3. Comparison of pre- and posttest perceived affordance regarding expectations about the four smartphone interaction tasks studied.

Table 3. Paired Sample *t*-test for Perceived Affordance on Levels of Expectation for Tasks via a Smartphone Interface.

	Mean Difference	Standard Deviation	Standard Error Mean	95% Confidence Interval of the Difference		*t*	*df*	Significance (2-tail)	Cohen's *d*
				Lower	Upper				
Pair 1: Level of expectation on making a phone call	0.83	1.96	.22	.39	1.26	3.76	79	.00	0.62
Pair 2: Level of expectation on adding a contact	0.79	1.91	.21	.36	1.21	3.69	79	.00	0.50
Pair 3: Level of expectation on installing an app from the Google Play Store	0.10	1.72	.19	-.48	.28	-.52	79	.60	--
Pair 4: Level of expectation on using WhatsApp	0.49	1.29	.14	.20	.78	3.37	79	.00	0.60

For Task 3 (installing an app from the Google Play Store), the result shows that there is no statistically significant increase for the older adults installing mobile apps scores from premeasurement (M = 4.13, SD = 1.656) to postmeasurement (M = .23, SD = 1.835), t(79) = -0.52, p = 0.60 (two-tailed). The mean increase in using installing mobile apps scores was 0.100, with a 95% confidence interval ranging from -0.482–0.282. No effect size was required for further analysis. For Task 4 (using WhatsApp), the result shows a statistically significant decrease in the older adults using WhatsApp scores from premeasurement (M = 6.48, SD = 0.993) to postmeasurement (M = 5.99, SD = 1.317), t(79) = 3.373, p < 0.001 (two-tailed), d = 0.66. The mean decrease in using a phone call score was 0.488, with a 95% confidence interval ranging from 0.200–0.775. The effect size is medium.

To interpret the statistical result of perceived affordance on levels of expectation, Table 3 indicates a decrease in the pre/post measurements for Tasks 1 (making a phone call), 2 (adding contact), and 4 (using WhatsApp). This means the older adults perceived those tasks as more difficult after completion. Several reasons yield the decreasing score for those three tasks. For Task 1, making a phone call, some older adults had problems identifying and locating the keypad phone icon (explained more fully below) due to the not-easily-comprehensible icon design. For Task 2, the older adult participants were not familiar with the menu structure of Samsung S7 phone, and thus some had difficulties in completing properly the task of adding a new contact. In Task 4, using WhatsApp, the majority of participants had no problems in sending a message. However, most experienced difficulty in recording and sending an audio file using WhatsApp (detailed below). Therefore, these challenges resulted in a negative experience for the older adults and reduced their favorable impressions of performing those three tasks. In another words, the participants struggled to complete certain subtasks on a smartphone user interface with features unfamiliar to them or because of the inappropriateness of icon location, both of which yielded an affordance gap.

Result of Qualitative Data

Following the posttest and debriefing, we conducted qualitative analysis using NVivo 12 Plus from the observation field notes and interviews. The themes emerging from the analysis reveal how the older adults perceived their expectations regarding the interaction tasks. We identified five themes: (a) a mismatch between user–task interaction and user expectation, (b) prior knowledge or product experience, (c) visual appearance of the smartphone user interface, (d) the visibility of icon location, and (e) participants' seeking help and guidance. Each of these themes are addressed more fully below.

Mismatch Between User Expectation and User-task Interaction

Based on our observation, a majority of the participants expressed disappointment and/or a negative experience in dealing with Tasks 2, 3, and 4. They identified the most problematic subtask as the recording and sending an audio file using WhatsApp. As mentioned earlier, most of the older adults were using smartphones given to them by their children or relatives as gifts or hand-me-down devices. Moreover, the respondents indicated that the main motivation for them to adopt a smartphone was to use WhatsApp to send and receive media files (messages, photos, and videos) to stay connected with their family members and friends. However, for this subgroup of smartphone users, almost all the mobile applications on their smartphones other than WhatsApp were installed already when they received it. Further, they typically were not given proper guidance on how to use and operate their smartphones. As a result, Task 3 was considerably challenging and the first time most of the participants used the Google Play Store to download and install a mobile app. The following quotations from the data indicate their struggle.

> *This is my first time trying to download a mobile app. I really have no clue how to do it. I expect the Play Store is like a game store because the name is "play" store.* (P13, Female, aged 69)[1]
>
> *I really have no idea of the function and what is it of the Play Store.* (P38, Male, aged 66)

> *It is so difficult* [to download the flashlight app]. *That's the biggest problem for me. Very difficult.* (P40, Male, aged 72)
>
> [Researcher: Did the Play Store feature have the function as you expected it to be?] *That one I am doubtful…* [Researcher: What do you expect the function to be?] *More precise, you know? Instead of searching, you touch* [on the screen] *and you should get all the features here. I don't know what to do. Instead, I have to roll, roll, and roll* [i.e., scroll, scroll, and scroll], *and nothing appeared* [frustrated sigh]. (P40, Male, aged 72)
>
> [For the Play Store] *Hmm, for my age, I don't need the games. For kids, it is ok, like games or entertainment or whatever. But for adults like me, maybe more serious stuff like Bloomberg, the* Star News, National Geographic. *For Muslims, maybe prayer time. The other applications are not required.* (P8, Male, aged 72)

In terms of sending an audio file using WhatsApp, a majority of participants failed to record and send the audio file. The task completion rate for this subtask was 36.25%, considerably low, as compared to other subtasks using WhatsApp (i.e., sending a message, 81.88%, and sending a photo, 63.13%). Based on observation data, the challenge revealed usability issues and technical difficulties regarding the audio record function. After several attempts, the audio record files did not go through for quite a number of participants. It could have been due to the participants just pressing the audio record icon one time and then releasing rather than pressing and holding the icon for the entire time to voice record the message (see Figures 4 and 5). The participants were expected to press and hold the button to speak into the phone to activate the audio recording function. Therefore, we found a mismatch between the expectation of the user's mental model and the technical design of WhatsApp audio function, as clearly noted by the participants' comments on sending an audio file using WhatsApp.

> *I expect after pressing the mic button, I can speak and send. Ah! But, it does not work for me. I have to record first, then I can only send. It does not send. I really don't know how to send. Must be different… I have to get used to this new gadget.* (P40, Male, aged 72)
>
> *This is new to me. I really don't know what to do. I give up!* (P52, Male, aged 71)
>
> *It is frustrating using this audio feature. I had sent the audio files so many times already. How come I cannot hear?* (P36, Female, aged 69)

Prior Knowledge or Product Experience

To find out whether it was intuitive for the older adult informants to perform the four tasks, they were asked during the debriefing whether they drew on any prior knowledge (e.g., experience from using their previous phone or any other information) to complete the test activities. The results revealed that a majority of the respondents did not consciously draw on their prior knowledge to use phone/voice call feature and WhatsApp phone call function, even though previous experience had prepared them for using the new technology that mirrored their prior knowledge. A male participant (P9, aged 73) commented, *"I don't need any prior knowledge to learn how to make a phone call. This is easy."*

On the other hand, we received mixed comments regarding the need for prior knowledge or product experience in using the contacts feature. For instance, when a researcher asked how easy or difficult it was to add a contact onto the testing phone, a respondent replied, *"To my phone is easy, but to your phone is so difficult. I have no idea how to do it"* (P57, Female, aged 66).

Figure 4. The users were supposed to press and hold the audio record icon (bottom right) while recording on WhatsApp and release it when recording was complete to send. Although the instruction appeared above the audio record button, a majority did not understand the instruction well, resulted in failure to complete the task.

Figure 5. The system response following the failed attempts to create and send an audio file to the recipient demonstrated the technical difficulties experienced by the users in completing the task.

Almost every participant expressed his or her need to learn how to use the WhatsApp audio recording function and the Play Store feature to download and install a mobile app. For example, when the researcher asked, "Do you need any prior knowledge to learn to use WhatsApp?" a female informant (P2), aged 69, responded, "*If for receiving messages, I think it is easy and not complicated. But, if I want to send documents, pictures, this one I need practice.*" A similar question regarding using the Play Store resulted in the response, "*Yes, it needs prior knowledge a lot and I don't know how to use because they* [the functions] *have not been taught*" (P74, Male, aged 73).

The Visual Appearance of the Smartphone User Interface

The visual design of an icon plays an important role on the smartphone user interface. Often it determines the intuitiveness and perceived affordance for users in taking an action via the icon. Generally, the older adult participants had no problems identifying the phone/voice call icon. However, when the participants had to make a phone call on the Samsung S7 Edge, quite a number of them could not find the phone keypad icon for dialing. On this interface, the phone keypad icon was not visible, and the clues on where to find it (at the bottom right, under the Phone page, see Figure 6), were not evident. Some participants applied trial-and-error tactics

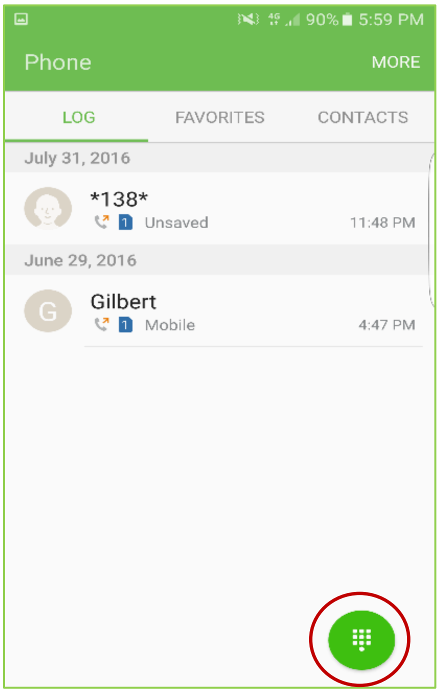

Figure 6. The phone keypad icon located at the bottom right of the phone page on Samsung S7 Edge (circle).

with few attempts, but some eventually gave up of making a call. In general, the older adults expressed their preference for a direct dialing page rather than finding the hidden and not-so-intuitive keypad design. They also lamented that the perceived phone keypad design was neither directly displayed nor intuitive to them, and it did not afford for direct dialing.

Basically, the older adults had no issues in recognizing the phone/voice call icon, as it was quite similar to their previous keypad phone or smartphone. However, quite a number of them were confused between the phone/voice call icon and the WhatsApp icon due to the similar color (white and green) and nearly identical icon design (Figure 7). A female older adult commented,

> *Well, WhatsApp and the phone icons look the same. It is so confusing to me…* [When prompted by the researcher for a suggestion] *Maybe it can be someone holding the phone for phone icon and for WhatsApp icon, it can be someone on the phone and writing.* (P36, Female, aged 69)

Many older adults also were confused and dissatisfied with the Google Play Store icon and its function. The Play Store nomenclature (see icon on Figure 7) seemed misleading to many of the older adult participants. From the comments expressed during the interviews, many perceived it as “playing games,” “shopping bags,” “luggage for traveling,” and a site presenting fun and entertainment for kids. They did not think the icon suggested a place to download mobile applications.

> *No wonder I don’t recognize it* [the Play Store icon]. *To me, I thought the* [Play Store] *was a traveling thing, TripAdvisor. It is like a suitcase or luggage for traveling.* [When asked for a suggestion for the Play Store icon design] *Maybe best to use an image of a video game, something fun or a toy. So game, ah… rather than luggage.* (P45, Female, aged 68)

Figure 7. The default first page of smartphone screen user interface for Samsung S7 Edge. It shows the WhatsApp icon (top row, second from the right), the Play Store icon (top row right and Phone/voice call icon (bottom row left).

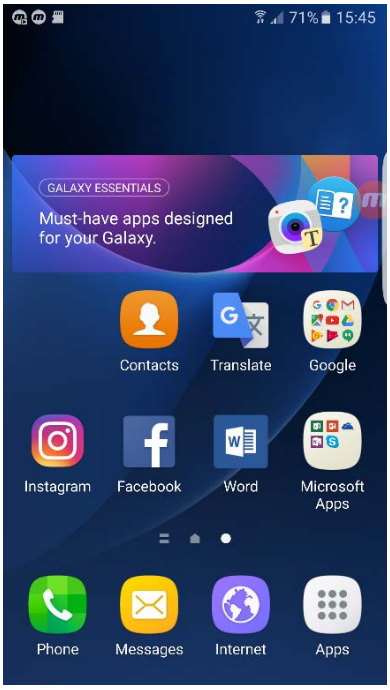

Figure 8. The first row of the default second page of the Samsung S7 Edge interface shows the Contacts icon. Some participants were frustrated at the location of the Contacts icon, feeling it should be placed on the first page, next to the Phone icon.

> *I thought it is for playing game; I expect it to be a chess symbol* [for the Play Store], *like games.* (P6, Female, aged 66)
>
> *I expect the function* [of the Play Store] *to be a play station. Is it for games only? This one I am not so sure.* (P9, Male, aged 73)

This highlights the affordance gap of user expectation (perceived from the visual design) and the external material world (the icon design of the Play Store). For example, a female user (aged 68) was an iPhone user and claimed herself not familiar with Android phone. She commented that she could not recognize the Play Store icon because she had no idea the icon was similar to the App Store icon on her iPhone.

Some of the participants also were not familiar with the use of the Contacts icon. For instance, a female participant (P45, aged 68) commented, "*We* [Apple iPhone users] *don't also have contact icon. The contact icon now looks like a clip art. I expect it to be more like a proper image. This one looks more feminine and mine looks more 'male'-like....*"

Visibility of Icon Location

Some older adult participants were lost in the navigation process for entering contact information on the Samsung S7 Edge smartphone. The study found that the location or position of apps icons on the smartphone user interface indicated the visibility of the icon appearance to the users. For example, the Contacts icon was positioned on the second page by default on the Samsung S7 Edge. As a result, some participants, who expected it to be placed next to the phone/voice call icon on the first page and not on the second page (Figures 7 and 8), were frustrated in their search for access.

Seeking Help and Guidance

Many older adult participants acknowledged that they are beginner or intermediate users of smartphones. In normal usage, when they faced problems in dealing with technical issues on their smartphones, they would contact their children, younger relatives (e.g., niece, nephew), or the mobile phone shop for help and technical support. For instance, one study participant told of resorting to asking help from a child younger than 10 years to solve quickly his technical problem.

> [Researcher: Do you get any support when you face any difficulties using the smartphones?] *Sometimes, small children, 7, 8 years old. They can handle it. That fella, a 10 years old boy, came to help me. I met him in the Sikh yard boy when I went to Melaka. The father was asking the son to handle my phone. The color* [of my phone is faded] *out. The boy repaired; then the color came back again. Fantastic boys nowadays… children, my golly! So I don't care. I don't feel shy.* [A] *9-year-old girl also taught me how to save to my Contact.* (P40, Male, aged 72)

Because mobile technology advances very quickly, quite a number of the older participants in this study expressed interest in attending smartphone trainings in their areas. Trainings of this nature are rarely available in Malaysia. However, the U3A has organized a series of Smartphone courses for seniors, taught by the first author, since 2011. The thinking behind initiating these trainings is that the older users' children or family members were not always available to assist the users in addressing a problem with their smart phone or may not have been patient in teaching their older family members some aspects of smartphone use. Thus, through guided learning, the smartphone courses help the older adult users deal with typical smartphone technical issues, such as media transfer and downloading apps from the Play Store, and expose them to useful apps.

DISCUSSION

In the first part of this section, we discuss the descriptive results from the participants' demographic profile and the smartphone usage. We then discuss the results derived from the statistical analysis of perceived affordance of level of expectation on the four tasks and present our interpretation of the qualitative data.

The phenomenon of older adults in Malaysia adopting smartphones is similar to that described in a study conducted in Spain (Rosales & Fernández-Ardèvol, 2016a, 2016b). Our interview results showed that the motivation of older adults for using smartphones parallel the reasons for using the feature phones: to communicate and staying in touch with their family and friends. Overall, the respondents cited WhatsApp as their favorite communication mobile app because they can access the service at no cost, as compared to using SMS (short messaging system) that has a per-use fee. Our interviews highlighted that the access to WhatsApp was highly motivating for the older users in adopting a smartphone, even if they found using it challenging, at least at first. They reported that using WhatsApp offers them the fun and fulfillment of knowing what is happening among their family and friends by sending messages and sharing photos and videos among themselves, something a feature phone could not provide. In addition, for those who had family members and relatives staying overseas, WhatsApp's ability in allowing them to make free calls, and more recently video calls, was the primary motivation for them to adopt the smartphone. In addition, despite any initial reluctance of and resistance to adopting a smartphone, peer pressure was another push factor that motivated the older adult participants to join their peers as senior smartphone users. That said, the older adult users in this study frequently did not explore the features and capabilities of smartphones beyond phone calls and WhatsApp, primarily due to the complexity of the smartphone user interface.

Many of our informants needed help to learn how to use the smartphone, and they always were perplexed on why their smartphones stopped responding to the task they are doing and, at the same time, the screen was frozen and slow in performance. Moreover, they often were afraid to access notifications on their phones because their children warned them that their phone could be infected with a virus if they simply clicked Accept. The older adult users also expressed a need for technical assistance because their children often were too busy or were not patient enough in guiding them in using their smartphones. When they faced a technical problem, they either had to wait for their children to become free to help solve the problem or contact a phone sales shop for help. However, what the respondents really wanted was to become empowered, to be able to solve their own problems, by gaining smartphone knowledge through attending training.

It was clear that when the older adults' needs are met—even if challenging at first—they are more likely to use their smartphones frequently. In some crucial ways, our data also revealed that smartphone user interfaces have not been designed to meet various specific needs of many older adult populations; the complexity of user interface features and overall usage are not intuitive to them, and thus smartphone use remains quite challenging for this segment of users.

The process of meeting user needs and expectations toward user adoption (taking action) is linked to Norman's (1998) EEAC model. For instance, when older adults are motivated by the clear goals of using a smartphone for communicating with their family and for media browsing and sharing, they are exposed regularly to the perceived affordance of a smartphone user interface (evaluation) and taking the action of sending or retrieving, for instance, a WhatsApp message (execution). During the Evaluation Stage (see Figure 1), it is crucial for the smartphone user interface (e.g., matching an easily identifiable phone icon design with its actual function) to meet the user's expectation (e.g., making a phone call). Successfully pairing the icon design with the expected process will lead the user to act appropriately by pressing the phone icon to make a phone call at the Execution stage.

Apparently, the mismatch between the participants' user perception and the smartphone user-interface design violated the usability heuristic of interface design (Inostroza et al., 2016; Nielsen, 1994; Silva et al., 2015). This led to a serious affordance gap between user perception and expectation. This means what the older adults perceived and intended to execute an action was not necessarily met, which led to the affordance gap. This is shown clearly in the result of paired sample *t*-test. It was not surprising that the commonly used phone tasks (i.e., making a call in Task 1, adding contacts in Task 2, and using WhatsApp in Task 4) are statistically significant in the level of expectation scores as compared to installing a mobile app. Having said this, the qualitative results served to complement and support the statistical results of perceived affordance. Thus, the results of Task 3 are unsurprising when considering that a majority of older adults, as supported by the results from our older informants, have little immediate interest in downloading a mobile app, and therefore would have no knowledge or experience regarding where to find apps or how to download them. In addition, our older users were afraid of downloading an incorrect mobile app, installing incorrectly, and/or inadvertently exposing their device to a virus. Therefore, they had little or no confidence in completing this task and preferred to leave installing apps to their children, who are more technically savvy.

The importance of icon design also surfaced as an important aspect of mobile app access. During the interview session, the older adults commented that the Google Play Store icon and label did not communicate its purpose as a site for mobile apps download. To many of them, the Play Store icon looked like a shopping bag; the name attached to the icon appeared more related to playing games. As a result, most of our informants did not discern that the Play Store icon had anything to do with downloading nongame apps. This indicates an affordance gap between what an older adult expects from function names and icons as compared to what they actually are. This gives rise to a recommendation to the Google Android phone designers that they need to critically reconsider icon design and appropriate labeling for mobile apps download and, in fact, any feature or function available to a diversity of users.

Although Task 3 (installing an app from the Google Play Store) showed an improved score at the posttask measurement, the overall score was still below 5 points and considerably lower when compared to the other three tasks, which all rated above 5 points regardless of their decreasing scores. This indicates that the older adults' participants in general still found difficult the process of installing a mobile app from the Play Store. This conclusion is supported by the qualitative analysis of the observation data and the interviews: The older adults were confused with the icon design and nomenclature of the Play Store and its perceived function.

Apart from visual appearance of icon design, the developers and designers also need to take into account various users' prior experience and/or product knowledge and how that impacts their perceiving an icon and its function. This was reflected in our findings that the older adults generally had no issue with identifying the phone/voice call feature due to the intuitive design and their prior experience of using the similar feature in their feature phone or previous smartphone device.

Language comprehension related to the smartphone interface and the research process in this study could have had an impact. However, although the Chinese comprised of 58.7% compared to other participants (27.5% Malay, 13.8% Indian and other ethnics), it was expected they could comprehend Mandarin well. Instead, some of them spoke Chinese dialects such as Cantonese, Hokkien, Teochew, and the like as their mother tongue. Overall, a majority of participants could speak, read, and write English and Bahasa Malaysia (the national language for Malaysia) very well as compared to Mandarin. This could be due to a few reasons. Firstly, the educational background of the old generation in Malaysia: They spoke well in English because Malaysia was a former British colony. Secondly, those who signed up to join the lifelong learning courses in the University of the Third Age (U3A) somehow were considered quite literate and fortunate to have received a better education during their younger days. This is evident in that 40% of our participants had received an upper secondary education and 50% of the participants had tertiary education. This implies that the participants recruited for this study were considered having high education backgrounds. The result showed that a majority have no problems of understanding the English language displayed on the smartphone user interface; only a few had to change to the Mandarin language on the testing device during the mobile-user interaction session. However, this result cannot be generalized to all older adults in Malaysia, based on their language proficiency in languages other than their own mother tongues.

Fundamentally, amid the burgeoning interest of older adults joining the legion of smartphone users, our data reinforce findings from studies in other contexts and user groups (Allen et al., 1993; de la Fuente, Gustafson, Twomey, & Bix, 2015; van de Kar & den Hengst, 2009) that mobile apps developers and designers must improve in incorporating the needs, interests, and consideration of perceived affordance into the design process. In terms of design recommendations, we suggest the design of smartphones or new technological designs needs to cater to the critical biological, psychological, and social needs of older adults. We also recommend that the mobile operator and telecommunication industries consider repackaging their marketing strategies and mobile subscription packages to account for older adults' socioeconomic requirements. For instance, a family subscription plan is a popular package introduced by the local mobile operators in Malaysia. The package accommodates not only the proliferation of extra share lines, but it also allows for broadband data plan extension.

CONCLUSIONS

With the increasing aging population worldwide adopting smartphones, much research has underscored how crucial it is to incorporate older adults' needs and to meet their expectations by reducing the affordance gap between smartphone UIs and user expectations. Older adults no longer want to be perceived as laggards (Rogers, 2003; Wong et al., 2017) or late adopters of smartphones. Although many previous smartphone studies have focused on the interests of young adults, the needs of older adults, who represent a growing market for smartphone use, are still not being met in the design of new technologies and mobile apps development. As our study found, many older adults find overall smartphone use complicated, and they require further technical assistance and/or training so that they no longer are forced to rely on their children or relatives for help.

The popularity of smartphones, and in particular WhatsApp as a favored communication app amid preferred health-care and utility mobile apps, have motivated older adults to adopt or trade up to smartphone capabilities. The results of this study provide useful information for mobile operators and the mobile development community (i.e., developers and designers) for capitalizing on untapped or underused opportunities within the growing aged 60+ smartphone user group. Commercial entities can draw on user experience and design strategies, marketing strategies, and mobile development strategies, supported by ongoing research, in meeting the specific needs of older smartphone users. The needs and interests of this older-adult cohort can be sidelined no longer; rather, they warrant important attention.

In terms of the limitations of this study, the participants selected represent a convenience sample and they were mainly from the Malaysian U3A (in Kuala Lumpur and Selangor), which are located in urban and suburban areas. Thus, the respondents are typically better educated and have access to more resources and services. Therefore, these findings cannot be generalized for the entire elder-aged population in Malaysia, particularly those from rural areas. Nevertheless, our findings reveal the needs and concerns of this so-called intellectual seniors cluster in how they use and perceive the smartphone. We also believe this subcluster group usually represents the early adopters among the older adult clusters. However, this study did not intend to explore whether the sociodemographic information—such as educational background, income, or language proficiency—influenced the older adult participants in adopting a smartphone. Yet these are worthy topics for future study. The same is true for continued investigation of our research concern: examining the affordance of perception and actions of smartphone use, particularly in older adults.

The four tasks selected for this study do not represent the entire smartphone user interface or mobile apps. The reason for choosing these tasks was to investigate the frequently used basic smartphone user interface features and mobile apps interests of older users. Again, although the result cannot be generalized to all aging populations in Malaysia or elsewhere, our findings reveal some behavioral interactions and perceptions toward smartphone user interfaces among the older adults. These topics remain useful topics for future study.

In conclusion, this paper has provided findings of and offered insight into the affordance gap in terms of levels of expectation. This study is part of a larger study that addresses smartphone user interface components, including visual design, icon location, and UI functionality that determine the perceived perception and possibility of actions (Blackler; 2006; O'Brien et al., 2007). That study, still in process, will present and discuss other affordance metrics (i.e., first-click accuracy and task accuracy measures) in association with smartphone user interface components and how prior product experience influences the perceived affordance stipulated in the affordance matrix based on Gaver's (1991) technological affordance framework in the future studies.

IMPLICATIONS FOR RESEARCH AND APPLICATION

This study lays the foundation for a nascent understanding of measuring expectation levels of perceived affordance on smartphone user interfaces for older adults. Our research presented a quantifying means for measuring the affordance gap via examining the levels of expectation. Our approach can be considered a novel approach for formulating Norman's (1998) execution/evaluation action cycle. The qualitative findings provide the insight into and valid reasons for Android developers and the mobile design community to improve their icon design, the phones' functionality, and the information architecture to accommodate older adults. By addressing the concerns and challenges surfaced about older and inexperienced users, smartphone and mobile app suppliers/designers can facilitate improved use across the larger users' base. Thus, this study underscores the importance of mobile apps designers, smartphone developers, and user-interface design researchers investigating or employing independent research regarding the older adults' needs and expectation for the smartphone user interface, and then incorporating recommendations to reduce user frustration and problematic action as early as possible.

ENDNOTE

1. All data quotes that were not spoken in English have been translated by the primary researcher and four qualified lecturers who are conversant in English and Bahasa Malaysia languages.

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UTILIZING DIGITAL TOOLS TO SUPPORT FACE-TO-FACE CARE: EXAMINING UPTAKE WITHIN THE PRACTICES OF AUSTRALIAN PSYCHOLOGISTS

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Abstract: *Societal adoption of mobile phones and other digital devices, and the resulting widespread digital literacy, allows for new possibilities in approaching and supporting face-to-face therapy. In this study, we examined the application of digital communication tools and media within therapeutic care by 33 psychologists across Australia. Uses of digital technologies were analyzed with a focus on both the approaches applied within face-to-face therapy sessions and those occurring as an adjunct to these sessions. In contrast to online counseling, established upon a foundation of digital technologies, the study results indicate that the use of technology in face-to-face therapy is still emerging but growing in scope and implementation. Areas of key and unique uptake by practitioners are identified, along with possibilities for future application. In outlining contemporary practices, a typology for the utilization of digital tools is presented, offering a practical framework for therapists to extend face-to-face care via information and communication technologies.*

Keywords: *face-to-face therapy, smartphone, digital literacy, mobile technology, digital health, face-to-face care.*

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INTRODUCTION

Alongside countries such as South Korea and Sweden, Australia has established itself as a key consumer and user of mobile devices in comparison to the rest of the world (Pew Research Center, 2019). In 2017, 88% of Australians were identified as owning a smartphone (Deloitte Australia, 2017), ensuring they had a continuous Internet access and were "connected" throughout their daily life. With this ubiquitous adoption of mobile devices, a subsequent change can be identified in the practices of education, work, retail, government services, travel, and socializing by Australians (Australian Communications and Media Authority, 2017; Fagan, 2017). Furthermore, technologies such as smartphones, with in-built digital cameras, are allowing not only continuous access to digital media but also media creation, which facilitates easy capturing aspects of life for private and public documentation and review. Such capabilities allow for even further changes across sectors.

In this study, we examined the response of therapists in Australia to the adoption of mobile phones and other digital devices, such as tablets and laptops, and to the increased digital literacy across Australian society. Specifically, we reviewed the changes and new approaches applied in traditional face-to-face therapy using common digital technologies as well as identified potential future directions for practice.

The Australian government continues to identify mental health treatment as an area of national priority and innovation (Commonwealth of Australia, 2009, 2017). It has been reported that 45% of Australians aged 16–85 will experience mental illness[1] in their lifetimes (Australian Institute of Health and Welfare, 2018), and that, according to a major survey conducted 12 years ago, one-in-five working-age Australians each year experiences a mental illness (Australian Bureau of Statistics, 2008). Throughout the last decade, in response to these statistics, sustained focus has catalyzed development and application of digital technologies in online therapy and e-mental health initiatives throughout the country. As a result, Australia is regarded as a world pioneer—alongside the Netherlands, Sweden, the United States of America, and Canada—in developing e-health technologies and online programs for common mental health conditions such as anxiety and depression (Christensen & Petrie, 2013; Orman & O'Dea, 2018). Such initiatives have resulted in the emergence of a number of successful nationwide online services, including ReachOut.com, e-couch, and BluePages, among others (Christensen et al., 2014). Despite this success and the online services providing larger scale and cheaper access to people struggling with mental health issues, a perception continues that face-to-face mental health services provide more effective and better quality support to people (Casey & Clough, 2016; March et al., 2018). The in-person model is regarded as preferable because it is perceived as more trustworthy and allows for a greater level of engagement (March et al., 2018).

Within this context, we evaluated the level of change in practices occurring within the face-to-face care by a small sample of accredited Australian psychologists amid the digital transformation in Australian society. In doing so, the research operated as a pilot study, allowing us to begin to address a distinct research gap within the field of therapeutic care and the use of digital technologies. Through our research, we gauged the extent and type of digital technology and media use among a sample of practitioners by, firstly, identifying any forms of digital technology being applied and, secondly, examining the methods and approaches employed with this technology, both within face-to-face therapy sessions and those occurring as an adjunct to these sessions. As well, we explored the participants' future expectations and aspirations for the use of technology within practice, which also serves to identify areas of resistance or concern.

TECHNOLOGY AND THERAPEUTIC CARE

The application of technology in face-to-face mental health care continues to be contentious (Feijt, de Kort, Bongers, & IJsselsteljn, 2018; Perle, Langsam, & Nierenberg, 2011; Richards, Simpson, Bastiampillai, Pietrabissa, & Castelnuovo, 2016). Present-day face-to-face therapy, operating in a similar format to Sigmund Freud's foundational practice, is based at its core upon direct communication and interaction between the therapist and client in a private setting. In this context, issues are explored through conversation and areas for change identified and approached. Because traditional therapy is driven by intimate discussion, many practitioners hold the attitude that the presence of technology in its various forms could detract from therapy's prime focus (Haberstroh, Parr, Bradley, Morgan-Fleming, & Gee, 2008; Lovejoy, Demireva, Grayson, & McNamara, 2009; Richards et al., 2016). This opinion exists despite that care often has utilized pen-and-paper activities and other therapeutic tools to stimulate reflection and discussion.

Possibilities for the use of technology in face-to-face therapy continue to be considered, however, resulting from the emergence and evidence-based success of online therapy and e-mental health (Perle et al., 2011). This constantly expanding branch of therapy—also referred to as online counseling, Web counseling, Internet psychotherapy, and other terms in different contexts (Barak, Klein, & Proudfoot, 2009; Kyrios & Thomas, 2014; Patrick, 2007)—in contrast to face-to-face therapy, utilizes technology as an integral component in the therapeutic process. This area operates with diverse modalities (Barak, Hen, Boniel-Nissim, & Shapira, 2008; Casey & Clough 2016; Lal & Adair, 2014; Short & Thomas, 2015) and entails therapy enacted through both real-time communication via chat rooms and/or video conferencing (synchronous communication) and time-delayed communication, such as through e-mail or message interfaces (asynchronous communication). Further, online therapy has led to models referred to as "therapist-less therapy" (Short & Thomas, 2015, p. 36), which can include custom-designed apps and websites used to guide clients (or users) through a series of resources and activities, some of which track and respond to progress. Therapist-less care also has been proposed around robotic solutions and virtual reality (Christensen & Petrie, 2013). Mohr, Burns, Schueller, Clarke, and Klinkman (2013) referred to such initiatives as "machine-powered interventions," which further distinguishes them from traditional therapist-delivered services.

It is now becoming common for psychological care to be addressed solely online and outside face-to-face therapy (Clough & Casey, 2011a; Gupta & Agrawal, 2012). Increasingly, research has demonstrated that these technology-driven approaches are as effective as face-to-face care (Andrews, Cuijpers, Craske, McEvoy, & Titov, 2010; Barak et al., 2008; Cuijpers et al., 2009; Firth et al., 2017). Despite this research, the application of technology in treating mental illness continues to be debated (Baker & Ray, 2011; Barrett & Gershkovich, 2014; Harris & Birnbaum, 2015; Perle et al., 2011) and face-to-face therapy continues to play a central role in treating mental health issues.

Although research examining the use of digital technology within face-to-face therapeutic interventions has been limited (Boschen, 2009a, 2009b; Clough & Casey, 2011a, 2011b, 2015; Eonta et al., 2011), some technologies increasingly have been integrated successfully. Clough and Casey (2011a, 2011b) identified a series of unique approaches that mobile adoption can provide to face-to-face therapy, including with ecological momentary assessment, previously conducted with pen and pencil questionnaires, and the delivery of relaxation exercises. Studies also have indicated that client adherence to the therapeutic process can be encouraged by what can be referred to as a “non-intrusive connection” (Clough & Casey, 2011b; Richards & Simpson, 2015). A consequence of this approach can be that, via a smartphone, other digital communication technology, e-mails, texts, and the like, clients may perceive that her or his therapy is extended beyond the traditional 1-hour consultation per week. Providing therapy support in such a way has been found to improve self-monitoring (Harrison et al., 2011; Wiederhold, 2012) as well as between-session engagement, homework compliance, and appointment attendance (Boschen, 2009a; Clough & Casey, 2011b; Murdoch & Connor-Greene, 2000).

Recently, Orman (as cited in Lyons, 2018) emphasized the strengths in using various types of existing e-therapy in combination with face-to-face care to address multiple conditions. Orman suggested a therapist might focus on deeper relationship-based therapy in-person with a client, while the client simultaneously engages e-mental health resources to learn basic skills. To explicate this multitiered approach, Orman illustrated with a client who suffered from an eating disorder and severe anxiety, a common experience for many people worldwide. The client would access anxiety management skills through an online program, leaving more time for addressing the many complex, often foundational, issues of the disorder within face-to-face sessions. Such a best-practices strategy, which sees combining e-mental health resources with face-to-face therapy approaches, has been recognized recently and accepted as a comprehensive therapy model by the Royal Australian College of General Practitioners (2018).

Limited research also has been conducted into applying mobile phones and digital technologies as part of face-to-face care through the use of digital videos, audio files, and photos (Boschen, 2009a; Boschen & Casey, 2008; Eonta et al., 2011). In this process, a client accesses mixed media content via a device, records such content on it, and utilizes it in different contexts. Recording content has been explored specifically within the treatment of phobias. Boschen and Casey (2008) observed how a client who is arachnophobic can record, via his or her mobile phone, pictures or videos of a spider then use this material in face-to face care and subsequent homework exercises based on exposure. Further, Eonta et al. (2011) outlined three case studies in which media were recorded onto smartphones, demonstrating the diverse ways such a model can support therapeutic care. Their first example, related to compulsive hoarding, entailed a series of digital photos taken by a client in an ongoing basis documenting her home. This material was used in therapy sessions to identify progress in relation to the behavioral pattern. The second example involved the audio recording of in-session relaxation exercises led by a therapist. Following this, the client accessed this material outside of therapy via a digital device for ongoing use. The final example entailed a client using a smartphone to photograph material on a white board developed during a therapy session. The resulting image, constituting a pie chart in the client’s handwriting, then became discreetly accessible to the client at all times on a phone, thus serving as a beneficial tool in developing the client’s cognitive coping skills.

Clearly, such examples identify valuable possibilities for the use of digital tools to support therapy. However, research identifying the level in which these approaches are employed has yet to be explored within or integrated into the practice of contemporary psychologists.

METHOD

We undertook our pilot study into current digital use practices through the distribution of an anonymous online survey to a sample of accredited Australian psychologists. The psychologists were alerted to the survey by the Australian Psychological Society (APS), the national body for certified practitioners, who distributed the survey information and a survey link. The APS announced the survey through both a short article in the members' section on their website and in their digital newsletter, *APS Matters*, sent directly to members via e-mail. This focused distribution approach ensured the authenticity of participants and that all were certified therapists (i.e., licensed therapists with a master's or doctorate degree). Participation occurred on a voluntary basis and with no compensation offered. The distribution channel for the survey information meant that all digitally connected APS members (approximately 24,000 professionals across Australia) received the invitation to participate in this study. Despite this large potential base, we expected that the overall response rate for the study would be low and suitable only for a pilot study. We based our expectation on the fact that multiple research surveys and studies are promoted frequently through the APS network; it is the primary means of engaging practitioners nationally. Thus, due to the volume of research requests, it is common for members to opt in to studies in which they have a particular interest. As a result, typical research participation through this distribution channel remains low. This study comprised 33 participants.

The survey (Queensland University of Technology Ethics Board approval number 1600001150) consisted of four central questions:

1. Which best describes your area of specialization?

This operated as a simple multiple-choice question that allowed each participant to identify her or his professional background. The options offered were Private Practice, Educational Institution, Other Government, and Other Non-Government.

2. Have you used any digital tools as a complement to or element in your face-to-face care with clients?

In the survey, the term "digital tools" was defined as the application of digital video, digital audio recordings, Portable Document Format (PDF) files, e-mail, texting, social media, digital video conferencing (e.g., Skype), and other Web-based or digital resources. This encompassed the major forms of interaction and communication processes available via smartphones and other digital devices (iPads, laptops, etc.). The scope of the technologies included was determined through reference material (Goggin & Hjorth, 2014; PC Magazine, 2017). In cases where the participants indicated applying digital tools, the system generated another question asking respondents to identify, from a list based on the definition, which tools were used. For each category identified in this question, respondents were asked to supply details of their digital application in an open-ended format. This allowed participants to detail multiple types of application across the one category.

3. What opportunities can you see for the use of digital tools in your therapeutic care with clients but have not employed for use at this point? If none, please indicate this and provide any additional comments you may like to add.

This open-ended question allowed participants to identify further areas of interest and to speculate on their own future practices. It also provided an opportunity to critique the use of digital tools in therapy and identify barriers to implementation.

4. In general, how comfortable are you using new technology?

This question allowed participants to reflect on their perceived levels of digital literacy using a 5-point Likert scale. Participants were asked to identify their relative comfort with using new technologies in a range from *very comfortable* to *very uncomfortable*.

We used the KeySurvey software to create the online survey, with a secure connection feature applied, and it was hosted on a Queensland University of Technology server. Data reflecting the response configuration of the survey indicated that informants took between 10 and 40 minutes to complete the survey, depending on the participants' experiences.

The methods for data analysis involved a statistical analysis of the closed-ended questions and thematic analysis of written responses to the open-ended questions. All responses were anonymous yet trackable to individual respondents through the generation of reports using KeySurvey. Due to the small sample size ($N = 33$), we researchers undertook the qualitative analysis by hand, without software. In reviewing the qualitative data, both researchers independently analyzed responses in order to authenticate emerging patterns and themes (Guest, MacQueen, & Namey, 2012). Responses indicating unique approaches to practice also were identified in the data analysis and incorporated into overall findings. We then developed a conceptual typology of practice using the established four-step process based on commonality and variation (Given, 2012).

RESULTS

The 33 psychologists from across Australia who participated in the pilot study outlined their current usage of digital tools within their face-to face care, as well as views on future technological application and issues surrounding this. All the participants completed the survey in its entirety and the sample represents a small selection from the greater body of psychologists around the country. Participants came from a mix of professional backgrounds: The majority came from private practice (19 participants; 58%), with the remainder from educational institutions (6 participants; 18%), other government organizations (4 participants; 12%), and other nongovernment institutions (4 participants; 12%). A large majority (27 participants; 82%) reported being comfortable with using new technology, opting to say they were either "comfortable" or "very comfortable" on the five-point Likert scale. Only two respondents (6%) indicated they felt "uncomfortable" or "very uncomfortable" when using new technology.

Digital Tools Usage

Of the 33 psychologists, 31 (94%) indicated that they had used digital tools as an element of, or complement to, their face-to-face therapy with clients. When the positive respondents were asked to identify specific digital tools from a list of categories, they selected several. Figure 1 displays the quantitative responses from the sample group. Findings based on replies to the prompted open-ended questions relating to each category and detailing the type of usage are provided below.

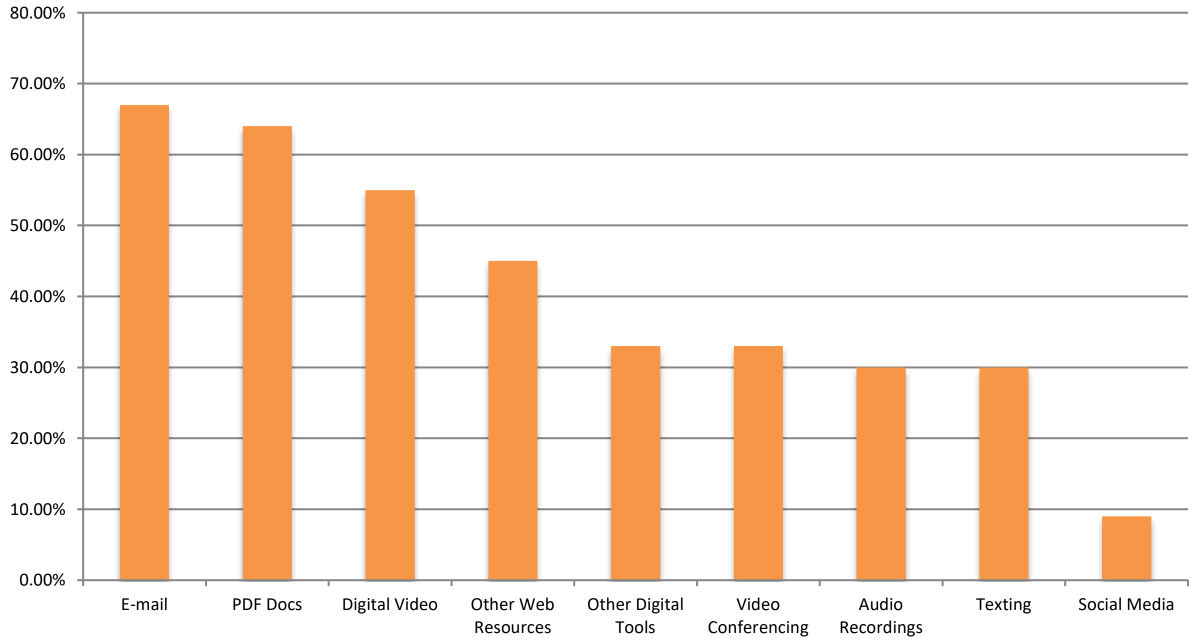

Figure 1. Use of digital tools by Australian psychologists within face-to-face care.

E-mail

In all cases, e-mail was utilized as an adjunct to face-to-face therapy, and in most cases, it was used for communicating with clients on a purely administrative level. Key usage included organizing and confirming appointments, reminding clients about appointments, and distributing PDFs for homework and supplementary reading.

Half of the respondents within this category (11 participants) also reported an additional use beyond administrative functions, where e-mail communication provided further therapeutic support. These respondents indicated this typically involved responding to clients who e-mailed when in crisis. Additionally, therapists cited using e-mail communication to undertake checkups and participate in general problem solving with clients. Notably, some respondents were critical of this form of communication, with one observing, “This has become a 24/7 sort of society, and with that comes the blurred lines of boundaries.”

PDF Documents

PDF files were used within the therapeutic practice of 21 respondents. These files resemble a printed document but can be sent and retrieved on digital devices, such as a smartphone. Moreover, PDFs may include interactive elements, allowing readers to input information into a document and return it via e-mail to the sender. Respondents indicated they typically used PDFs to replace traditional paper printouts of homework and reading material.

An advantage of PDF use as indicated across responses was that, although paper printouts necessitate distribution to clients during therapy sessions, PDF documents could be sent to clients at any time, including in times of need. Respondents indicated that PDF material sent to clients also included tip sheets, brief exercise handouts, and, frequently, psychoeducation-based selected readings. Although most material distributed was preexisting and selected by the therapist for specific use by a client, two respondents indicated they also had created original PDF-based material for clients.

Digital Video

Half of the respondents who cited digital video usage (9 of 18 participants) employed multiple forms of digital application (i.e., more than one type) within therapeutic practice. The most commonly applied by the therapists was the selection, or curation, of specific, preexisting content from a video sharing platform, such as YouTube or Vimeo, for a client to view. This was employed by 17 participants in the sample group. Respondents indicated that they typically selected material for one of two key purposes: to assist clients who needed additional support outside counseling hours or to provide materials as part of a defined homework program. The two primary video content subject areas indicated by respondents were mindfulness/relaxation-based materials and psychoeducation-based materials. Mindfulness and relaxation materials ranged from professional mindfulness training videos (including ones designed for children) to relaxation music videos consisting of "chillout" soundtracks[2] accompanied by images of nature and other graphics; these typically had been uploaded by independent video makers. Cited psychoeducation materials included both general information videos and guided practice videos.

Thirteen respondents in this category (72%) identified that viewing video material occurred outside, rather than during, face-to-face therapy sessions. In the case of respondents identifying that they had clients watch short videos within therapy sessions (five participants), this viewing served as a stimulus for subsequent face-to-face discussion. In the case of two respondents, this involved viewing clips of specific scenes from movies that were available on YouTube and Vimeo, indicating an application of cinema therapy (Short & Thomas, 2015). For the three remaining respondents, this entailed clients viewing originally created video content within therapy sessions, which occurred in two distinct ways. The first involved clients showing videos to the therapist that they had shot outside of therapy, and this formed the basis for reflection and discussion within a session. An example identified here was a video of a parent (the client) and their children interacting; the parent and therapist viewed this footage during their session to discuss "parenting strengths and struggles." The second approach entailed the therapist showing videos previously recorded within therapy sessions with client consent as a focus for discussion. The participant utilizing this approach stated that this allowed for explicit feedback to occur with clients to "improve skill development and raise self-awareness."

Digital Video Conferencing

Within the sample, 11 respondents indicated they had used video conferencing (e.g., Skype, Zoom, etc.) as an alternative to in-person face-to-face therapy when circumstances necessitated it. Reasons identified for this were where a client was overseas for an extended time, relocated elsewhere temporarily or permanently, or housebound. Respondents acknowledged that clients covered by private health care were far more likely to utilize video conferencing as an alternative to in-person face-to-face sessions, while those relying on public health care were less so. The reason cited for this reality is that currently only in-person face-to-face sessions are covered by the Australian public health system (Medicare) with a financial rebate.

Digital Audio Recordings

Although the application of digital video varied, the usage of digital audio was consistent across respondents. Nine of the 10 participants who reported using digital audio recordings identified that these exclusively consisted of meditation and relaxation-based recordings for clients. Entailed here was a combination of guided meditations, guided breathing exercises, relaxation music, and nature soundtracks. In all instances, respondents used preexisting online material and no therapist indicated self-produced audio material. In all cases, nearly all clients utilized this audio material outside face-to-face sessions, not within.

One respondent did report employing audio recordings within therapy and this involved original client-created audio recordings. This same practitioner used original video recordings of a client interacting with their children. In the case of the audio recordings, audio was recorded by the client to document daily activities and communication for discussion within sessions with the therapist.

Texting

Ten participants reported texting clients. As with e-mail, texting was used predominantly as an administrative tool, particularly for appointment scheduling and reminders. Additionally, four of these respondents indicated a further use of texting in a therapeutic-based capacity. In this context, respondents identified that they may text with clients to encourage or chat with them on a specific topic. One participant stated texting had replaced the need for phone conversations with clients, hence allowing for a typically asynchronous form of communication rather than immediate verbal communication. Texting for this type of communication was identified as being easier to manage than phone calls with clients.

Social Media

Only three participants cited using social media within their practice. Social media encompasses websites and applications that allow users to create and share content and to engage in social networking. It includes platforms such as Facebook, Twitter, LinkedIn, Google+, Instagram, SnapChat, WeChat, Instagram, and Pinterest. Respondents employing social media reported its primary use was to distribute therapeutic material and communicate information to clients, with therapists opting to do this via a client's social media account rather than e-mail. In describing the use of social media, no respondent indicated reviewing a client's social media profile and/or posts as part of therapy, or having a client access a social media profile during face-to-face sessions for discussion or reflection.

One respondent did report establishing a closed social media group, consisting of a number of clients experiencing similar conditions. This respondent posted directly to this group and encouraged members to network and support each other through social media communication.

Other Web-based Resources

Fifteen respondents (45%) reported that they used additional Web-based resources as elements of and/or complements to face-to-face therapy, with all utilizing specific websites. The most referenced websites were Smiling Mind, followed closely by Beyond Blue, Headspace, and MoodGym. Smiling Mind[3] is an Australian not-for-profit organization site providing mindfulness meditation programs. Beyond Blue[4] is an Australian not-for-profit organization site addressing and raising understanding of anxiety disorders, depression, and other mental disorders. Headspace[5] is part of a government initiative addressing Australian youth's mental health and well-being; the site offers support on issues including depression, sexuality, bullying, and alcohol and drug use. MoodGym[6] is a website based on cognitive behavior therapy principles developed by the Australian National University to assist treatment of depression.

In terms of other Web-based resources, five respondents also identified using some form of online assessment tool or service to assist during client therapy. In most cases, this tool or service was located on the website(s) used as part of care.

Other Digital Tools

Further, 11 participants (35%) reported using other digital tools within their practices that were not previously mentioned in the survey. All respondents except one specifically cited the use of multiple apps. Apps are software programs downloadable onto a mobile device, designed for a specific purpose, and typically are used on a continuing basis. In the survey, the most regularly applied apps identified were Smiling Mind and BeyondNow (the Beyond Blue app), both of which are connected to parent websites. Like the website, the Smiling Mind app supports mindfulness and meditation practice. In contrast, the BeyondNow app is aimed specifically at suicide prevention.

Respondents further identified utilizing a range of apps to promote behavioral change and allow behavioral tracking by clients. This included a variety of general-use mindfulness apps as well as mood tracking apps. Also utilized were everyday health-based apps, with respondents remarking that these assisted clients with fitness and healthy eating, which benefitted overall well-being. Four respondents identified using apps specifically designed to support the treatment of alcohol and drug issues, with two reporting utilizing alcohol-monitoring apps. Two respondents also cited the use of sleep monitoring and sleep assistance apps for clients.

Beyond respondents identifying the use of apps, one noted a further use of mobile phones as a digital tool for care. This entailed having clients set their mobile phone alarms for times throughout each day to provide a series of reminders to cue new behavior and thinking.

Identifying Future Applications of Digital Tools within Practice

From the question asking participants to comment on perceived opportunities for digital tool usage in future practice, we identified a variety of options. Most cited, by 25% of the participants, was using video conferencing as an adjunct to, but not replacing, face-to-face therapy sessions. Respondents here acknowledged, however, that the current Australian government public health system policy did not support moving in this direction.

Within the sample, five respondents also showed specific interest in utilizing new tools, especially apps, to allow them to better evaluate and monitor clients through tracking. Respondents in this case, though, did note they were uncertain of options available for this. Two respondents stated they desired an evidence-based and accredited all-in-one app. It was suggested that this type of innovation would allow a therapist to easily customize complete treatment plans and tracking tools for clients and then to utilize this throughout care. Some proposed that such an app could allow a therapist to select and design interactive homework activities for clients, create and curate reading material and video content for clients, provide appointment details and reminders, and allow for asynchronous digital communication between therapist and client.

In terms of suggesting areas of future practice, the majority of respondents identified areas of technological use already evident in the practice of other participants within the study. For example, a number cited filming the clients or having clients film aspects of their lives on their smartphones, and utilizing these clips within face-to-face therapy sessions. One respondent expressed interest in recording actual therapy sessions and then replaying them to clients as a means to discuss progress in treatment.

Four respondents also identified possibilities in recording original content for clients that they could access outside of therapy sessions via devices. One respondent indicated an opportunity to create instructional videos that demonstrated breathing techniques to clients, while another had a desire to record personalized cognitive behavior therapy material in video and audio formats for clients to access on their mobiles.

Markedly, within the study's speculative section, one third of participants identified either a general uncertainty or lack of knowledge of further opportunities for the use of technology within face-to-face care. Within this group, four respondents pointed to a distinct need for further education for therapists in this area of practice. Related to this, more than half of the respondents (17 participants), throughout the entire survey, raised the issue of requiring more educational training and guidance relating to technology application in face-to-face care. In addition, some respondents raised specific concerns about any use of social media in association with practice, citing professional boundaries as an issue.

DISCUSSION

Within the sample of practitioners, albeit limited, evidence suggests that a transformation of practice is occurring as digital technologies are utilized within and as an adjunct to face-to-face therapy. This transformation, however, appears inconsistent across our group of informants and we identified a gap in educational support to assist the occurring change in practice. It bears acknowledging that the study reflects a self-selected group of individuals identifying themselves as generally tech savvy; all respondents showed an interest in actively participating in the study, even without compensation. One might surmise that a random sample of practitioners across the country may be less knowledgeable and/or disinclined to apply digital technologies. Further investigation is warranted to determine the strength of that supposition.

Even though the sample group is small, the results serve to reflect a series of case studies and to identify insights from multiple contemporary therapeutic practices that are greatly needed within this emerging field. As a pilot study, our research results demonstrate that further research is required on a large scale to ascertain levels of implementation, educational needs, and opportunities for future practice.

The participants in this study indicated a desire to utilize technologies within their practices when appropriate and beneficial to clients. On the other hand, they expressed a general uncertainty about the various approaches. A large-scale study could serve to highlight and validate new models for integrating digital media into mental health services and to further educate counseling professionals. An acknowledgement of educational limitations in this area also has been indicated within *e-Mental Health: A Guide for GPs*, produced by the Royal Australian College of General Practitioners (2018). Likewise, Firth et al. (2017, p. 21) suggested, “Future research should investigate pragmatic approaches for integrating smartphone support within existing health services.” Initiatives such as eMHPrac, the e-Mental Health in Practice project, funded by the Australian Government, aim to raise practitioners’ (i.e., general practitioners, therapists, other health officials) awareness and knowledge of digital technologies and therapeutic tools (eMHPrac, 2018). However, this initiative is based largely on connecting practitioners to tested online therapy resources. Not currently incorporated into any such approaches is the reporting, analysis, and dissemination of the more experimental practices emerging specifically within face-to-face therapy.

With the aim of further educating practitioners, the findings of this pilot study offered insights into a foundation for a practical framework for therapists in considering applying digital tools within face-to-face care. Drawing from the study’s findings is a typology, displayed in Figure 2, which shows the various ways smartphone and digital technologies are currently employed and could be utilized within contemporary practice. This typology allows practitioners to better consider options and opportunities as they develop treatment plans for individual clients. The typology is categorized by type of usage, not the specific digital tool used. Thus, it explicitly allows practitioners to understand the possibilities for their practices with the increasing range of

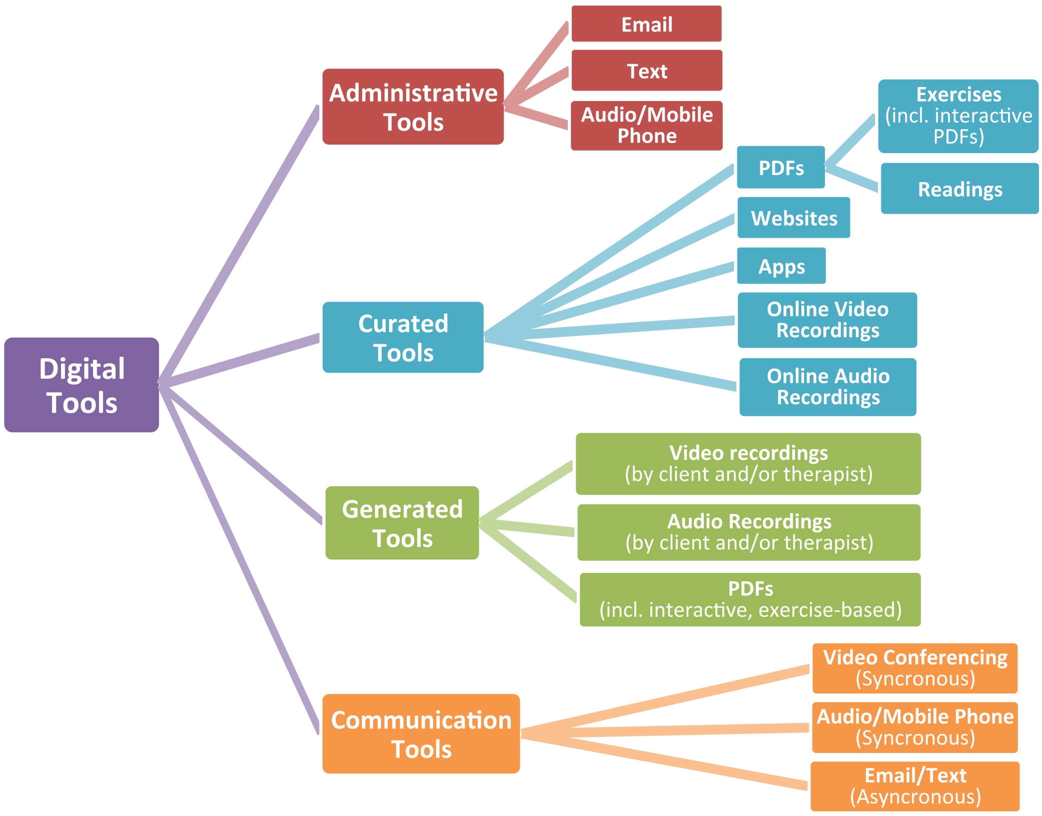

Figure 2. Typology of digital tools for use in face-to-face care.

emerging digital tools. It assists in identifying digital technologies that people use in everyday contexts as tools for specific actions and the potential for counseling contexts. Moreover, this typology supports interested therapists in navigating the diverse options and considering more efficiently what opportunities might best serve their therapy plan for a specific client.

The typology operates by dividing usage into four key categories: Administrative Tools, Curated Tools, Generated Tools, and Communication Tools. Administrative Tools encompasses tools for organizational services related to a client and her or his treatment and does not include the therapeutic process itself. Curated Tools relates to preexisting digital resources and material selected by a practitioner for use by a client. This category represents the most widely applied use of digital tools within face-to-face care identified within this study. In contrast, Generated Tools represent therapeutic resources created by the client and/or therapist using a smartphone or other digital device. This category highlights an emerging area of practice identified within the study, in which both therapist and client are producers of media and content that is intended specifically as a matter of treatment for the client. Significantly, this approach was referenced widely by the participants as a future expectation for use of digital technologies. Finally, Communication Tools encompasses digital technologies allowing therapeutic discussion to occur between therapist and client outside of in-person face-to-face therapy sessions, establishing therapy beyond the traditional “therapeutic hour.” This category encompasses both synchronous and asynchronous media forms.

In terms of future application, such a typology might be useful as a point of discussion with clients in identifying communication and media preferences when planning aspects of treatment. Determining a client’s individual needs and communication and media inclinations can allow therapists to select and even develop certain tools and technologies identified as more appropriate and meaningful in terms of potential impact. For example, rather than a practitioner automatically texting a client about appointment reminders and recommending selected digital readings for cognitive behavior therapy and YouTube videos on mindfulness, as they may do with other clients experiencing similar conditions, other approaches—tailored explicitly to the needs, preferences and abilities of a specific client—are actively considered. Undertaking a conversation with a client based around this typology could potentially identify more beneficial approaches. Due to privacy concerns, e-mail may be determined as preferable for messages to this client as opposed to less discreet text messages, or it might be established that she or he prefers video-based cognitive behavior therapy information rather than reading material because he or she is a visual learner. Through therapist–client discussion, it also may become apparent that an audio format is preferable for certain resource material because the client commutes on public transport daily and has an established routine amenable to listening to podcasts. Furthermore, through conversations centered upon this typology, a client may be prompted to express a desire to have access to specific material not otherwise considered. For example, while discussing the options within such a typology, the client might express a preference for recordings of mindfulness practices undertaken during the therapy sessions, as opposed to utilizing a third-party resource; such a tool would provide greater value as a client feels more connected to this for use outside of sessions.

From this study, a good number of our respondents have identified a variety of approaches and resources now being utilized within care. What is not evident, however, is how these tools and processes have been selected and whether practitioners have designed a unique digital media plan for each client. Utilizing a typology such as in Figure 2 provides a foundational structure for a more informed and considered way to integrate continually emerging digital resources into face-to-face care.

Utilizing Social Media Within and as an Adjunct to Face-to-Face Therapy

In developing this typology, a notable exclusion in it is arguably the most pervasive form of digital communication to emerge over the last 10 years: social media. Within the study, both in terms of current usage and identified future opportunities, minimal recognition was made of social media. Although some respondents acknowledged use of social media for administrative duties, other participants were highly critical or apprehensive of any use of it across practice. One exception to this was the sole respondent who established a closed social media group for clients experiencing a similar condition. As a result of the broad negative response, as well as the lack of engagement and consideration for future use, we did not integrate social media into the initial typology of practice, which is intended as a workable guide for therapists.

The lack of engagement and hesitation by respondents is understandable when one considers the minimal precedent for use and the potential ethical issues arising from integrating social media content and communication into therapy. Issues surrounding client privacy and encroaching on professional boundaries within this context have been documented (Giota & Kleftaras, 2014; Kolmes, 2010). Despite this, however, social media continues to be an integral part of everyday life for the majority of Australians (Deloitte Australia, 2017), and popular platforms such as Facebook have been reported as fostering high levels of self-disclosure through social sharing (Moreno et al., 2011). As a consequence, a potentially unprecedented resource exists through which to gain an insight into a client's situation, track progress, and anticipate issues.

Discourse attempting to establish an ethical position and distinct policy and framework in regard to social media continues to emerge across the literature (Anderson & Guyton, 2013; Giota & Kleftaras, 2014; Jordan et al., 2014; Reif & Much, 2017), and recent research has focused on less intrusive ways for client social media feeds to be tracked and reviewed. Responding to privacy concerns, anonymous "observer" data gathering technology and mood tracking data analytics are now being developed (De Choudhury, Gamon, Counts, & Horvitz, 2013; De Choudhury, Kiciman, Dredze, Coppersmith, & Kumar, 2016; Mohr, Zhang, & Schueller, 2017; Morris & Aguilera, 2012). In the future, therapists could feasibly employ such software to scan Facebook and other social media platform posts of identified clients for suicidal ideation and/or potential self-harm on an ongoing basis, with the practitioner notified if concerns are raised. While not an option currently, if technology continues to develop in this direction and therapists are guided by relevant policies, one can expect social media to be further integrated into the practice of face-to-face care and thereby future iterations of this typology of digital tools.

Further Implications for Practice: Designing for Breaks in Therapy

Within the application of digital tools identified in this study, it is evident that although some tools are utilized during therapy sessions, the majority play a role outside face-to-face sessions. This leads to a further consideration of digital tool use not identified specifically within the study, but warranting further exploration. This entails the development and application of such tools as an adjunct to face-to-face therapy, beyond face-to-face therapy. Situations where such tools could potentially benefit clients might be when a therapist takes an extended leave, face-to-face care becomes less frequent due to less overall need, or therapy ceases as a client completes treatment. Due to the media and technology options now available, therapists can offer a variety of personalized digital resources that may prove more beneficial than providing a series of standardized, printed resources, as is often the case in such scenarios. Instead, therapists can effectively design a unique set of digital tools to best support a client during a sustained break from therapy. A therapist may recommend and even create digital tools that reinforce key aspects of treatment and anticipate potential client setbacks. Within this context, the typology of digital tools could provide a comprehensive framework through which to develop a customized set of resources for specific therapeutic treatment or breaks.

In terms of application in this context, one could expect that not only curated tools but also generated tools are likely to be central to the provision of best digital therapeutic support. A therapist, for example, might record a series of personalized mindfulness meditations or cognitive behavior therapy guidance talks for a client in preparation for a break. Similarly, resources could be developed in anticipation of specific situations an individual client might face. For example, a therapist might create a digital video or audio recording to support a client with a history of travel anxiety for when she or he is undertaking a plane flight or to offer guidance to a client struggling with alcohol consumption in preparation for attending an event where alcohol will be freely available. In such cases, the resource material is formulated around the specific needs and communication preferences of the client and would be immediately accessible wherever the client may be, on a smartphone, even after therapy has ceased. Significantly, such customized tools can be accessed during potentially triggering events as they happen. Certainly these avenues indicate further possibilities in the adaptation of therapeutic practice within the changing technological landscape.

CONCLUSIONS

Opportunities abound for face-to-face therapeutic practice to be transformed as society moves further through its digital age. In this paper, we have identified how, for a sample of Australian psychologists, the move to extending care through new digital literacies and technologies is underway. At the same time, it demonstrates that this process is still just beginning. The study indicates a series of changes one might expect to see as digital and media transformations continue to advance across societies, and others that represent unprecedented developments in therapeutic practice. For instance, the adaptation of traditional print readings to digital PDF files and viewing online videos reflect a straightforward replacement for and complement to older technologies/approaches. This situation replicates much of what has been observed throughout the rise of the Internet and the digital age (Wellman & Haythornthwaite, 2002). Concurrent to this, however, are changes that are based not on simply updating to new media forms, but ones indicating more foundational shifts. Arguably, most significant here are practitioners and clients becoming content creators and utilizing what has been termed “generated tools” within this study. Such developments signal major innovation in how face-to-face therapeutic care can be undertaken in a contemporary context.

The findings of this pilot study indicate a need for further, large-scale research in the field to identify emerging practices and the future possibilities with digital technologies. While a limitation of the study has been its small sample, we are currently building upon this pilot study’s findings and engaging a greater volume of participants across the sector. Scaling up research in the field will serve to provide not only a deeper understanding of context and frequency but also allow for an exploration of evaluation processes and perceived levels of success and impediments within this emerging area. Future areas to be examined will include how a practitioner's level of training, age, or years of practice, as well as gender and location, might influence utilization of digital tools and how the demographic and diagnosis background of clients might inform how and when such tools are used.

Critically, the findings of this pilot study indicate a need for educational support and frameworks for practitioners to capitalize fully on the technological and digital literacy changes in society. This knowledge represents first steps in transitioning face-to-face therapy into the digital age, thereby following the transformation of many other practices and industries. Despite this, and the new possibilities for digital tools to enhance aspects of treatment, however, it is still evident that within face-to-face care the traditional approaches and techniques remain central and integral to practice.

IMPLICATIONS FOR THEORY, POLICY, AND APPLICATION

Although online mental health, or e-mental health, has dominated research into mental health care and digital technologies, a need is increasing for a separate body of work that focuses exclusively on technological use within face-to-face therapies. This pilot study serves to identify numerous emerging practices in the sector and therein a series of key areas that researchers can build upon and explore further. Through identifying unique practices, expectations, and key issues, a foundation for future research priorities and dialogue has been established. Furthermore, in this study representing one of the first to document the changes and perspectives relating to contemporary face-to-face care in this context, our findings contribute to industry discussions and policy development relating to relevant areas in therapeutic practice, including in relation to privacy and social media.

Alongside this, the typology of practice constructed from this study, drawn from the small sample of practitioners, represents a practical starting point through which professional therapists can identify and explore the possible use of digital tools for clients within face-to face care. Resources such as this typology serve to fill a current void in practitioner education. Moreover, such research can help make a case for governments, private insurance companies, and other funders of client therapy to rethink the components of professional therapy for the benefit of technology-savvy clients and practitioners. Significantly, the typology will be of benefit not only for practitioners in an Australian context, but across many countries where mobile usage is booming and digital literacy is increasing.

ENDNOTES

1. A mental illness is regarded as a health problem that can affect how a person feels, thinks, behaves, and interacts with people (Department of Health, 2019). The term mental disorder is used interchangeably to describe these types of health problems, and diagnosis occurs according to standardized criteria. Most mental illnesses can be treated effectively; however, some people experience reoccurrence throughout their lives.
2. Chillout music is a musical genre defined by soothing rhythms and mid-tempo beats. The term *chill* derives from street language meaning "relax," and the genre emerged in the early to mid-1990s in "chill

rooms" at nightclubs. In such rooms, mellow music was played for party goers as a way to unwind, away from more frenetic and fast-paced music played by regular club DJs (Chill Music, 2019).

3. An overview of the Smiling Mind meditation programs and links to resources are available at www.smilingmind.com.au
4. Full details of the Beyond Blue organization and its initiatives are outlined at www.beyondblue.org.au
5. Further information about headspace services is available at www.headspace.org.au
6. The Australian National University initiative can be accessed at www.moodgym.com.au and the Frequently Asked Questions section provides a concise summary of the program.

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INVESTIGATION OF UNIVERSITY STUDENTS' PERCEPTIONS OF THEIR EDUCATORS AS ROLE MODELS AND DESIGNERS OF DIGITALIZED CURRICULA

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Abstract: *Higher education graduates need 21st-century skills, both learning skills and competences for working with technology. However, research indicates an insufficient integration of ICTs into teaching and learning. In this paper, we examine students' perception of various technology-based issues: (a) ICT integration within a Slovenian university's learning environment, (b) teachers as role models for ICT use, and (c) the processes of collaboration and creativity as integrative parts featured in learning technologies. We studied beliefs about the contribution of ICT use to teaching and learning as the primary factors influencing ICT integration. A one-way ANOVA revealed that students in teacher education and education studies, as compared to students in other disciplines, perceive their teachers as effective designers of and as role models for ICT integration, although they do not perceive their teachers as leaders in new technology use. Effective leadership in technology innovation and the diversity of instructional design in guided and student-driven learning environments require continual curriculum development.*

Keywords: *higher education, teacher education, information communication technology, educational technology, teacher as a role model, teacher educator.*

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INTRODUCTION

Learning and innovation skills, the 4Cs (creativity, critical thinking, communication, and collaboration), skills for working with technology and in media-driven environments are, along with skills for work and life, integrative parts supporting subject-specific competences in the curriculum for the 21st century (Partnership for 21st-Century Skills [P21], 2012; P21 & American Association of Colleges of Teacher Education, [AACTE], 2010). Technology integration into teaching and learning makes an important contribution to graduates' readiness for the workplace. It differs across sectors and professional disciplines, with the educational sector ranking only 14th of 22 on the Sector Digitalisation Index (Manyika, 2015). Worldwide, 21st-century skills have been applied to national curricula (see, e.g., Siddiq, Gochyyev, & Wilson, 2017). Technology-supported teaching and learning offer the potential for developing skills in critical thinking, problem-solving, and communication (Instefjord & Munthe, 2017), collaboration (Darling-Hammond, 2017; Jääskelä, Häkkinen, & Rasku-Puttonen, 2017), and creativity (Idris & Nor, 2010; Loveless, Burton, & Turvey, 2003; Sang, Valcke, van Braak, & Tondeur, 2010).

Collaboration has been regarded as an integral part of technology-supported student-centered instruction and has widely been discussed (Means & Olson, 1997). The 2017 edition of the *NMC* [New Media Consortium] *Horizon Report* (Adams Becker et al., 2017) highlighted online collaboration as a means for developing 21st-century skills and technology adoption. In a series of recent reports on the essential learning technologies, noted educational consultant Donald Taylor (2017) twice (in 2015 and 2017) ranked collaborative and social learning at the top of his lists. Research in teacher education also has shown collaboration as an essential strategy in technology adoption (Hao & Lee, 2017; Hattie, 2009; Tondeur, van Braak, Siddiq, & Scherer, 2016).

The *NMC Horizon Report* in 2017 revealed inequality in access existed even though online learning resources are available so widely (Adams Becker et al., 2017). In particular, teaching and learning approaches do not apply information communication technologies (ICTs) optimally (Jääskelä et al., 2017). Students increasingly use ICTs in most aspects of their lives and expect universities to address their needs and preferences for ICT use in the institutional learning environment (McGraw-Hill, 2017). Appropriate ICT use significantly affects students' perceptions of the effectiveness of their courses (Venkatesh, Croteau, & Rabah, 2014). Prosser and Trigwell (2000) contended that students' perception of the higher education learning environment should guide teachers' pedagogical decisions because students' perceptions are critical in their academic success. However, Croteau, Venkatesh, Beaudry, and Rabah (2015) identified a gap between teachers' and students' perceptions about the contribution of ICTs to learning, and Hammond (2014) determined a gap between rhetoric and reality in terms of student-centered pedagogy in technology integration. A variety of reasons are reported for this:

- teachers from diverse disciplines in higher education feel they lack the pedagogical competences for technology integration (Conole, Dyke, Oliver, & Seale, 2004);
- the teachers' training in ICTs for the classroom focused more on technical knowledge rather than an integrated approach, thus making it inadequate (Mishra, Koehler, & Kereluik, 2009);
- a lack in dissemination of good practices (Ebert-May et al., 2011);
- a lack of research and training for ICT integration at the tertiary level of education (Instefjord & Munthe, 2017);

- a lack of understanding of higher education teachers' beliefs about technology-integrated teaching and learning (Jääskelä et al., 2017); and
- higher education teachers' negative beliefs about ICT integration for learning and insufficient interventions to transform them (Venkatesh et al., 2014).

Higher education is tasked with preparing graduates for work life and participation in societies undergoing a rapid and sustained diffusion of new technologies, as well as addressing the current digital divide that, in the developed world, refers mainly to skills access and usage access (Van Dijk, 2006). As a result, higher education environments require the capability for fusing the academic and professional spaces with the students' personal technology practices. The rate of integration of new technology depends on social and technical aspects and the users' learning curve. Communication channels and social networks disperse technology innovation and facilitate imitation behaviors that contribute to ICT adoption (Cantono & Silverberg, 2009), with teachers serving as role models and curriculum developers toward this end (Bouckaert & Koos, 2017). Thus, higher education is being required to adopt ICTs within the academic environment and to apply professional and learning technologies within the curricula that offer an authentic learning experience. Such practices also enable students to become early adopters of new technologies in their professional fields. Integrating professional ICTs in curricula accelerates the learning curve of graduates in meeting the ICT requirements of the professional workplace. Differences in ICT implementation in teaching and learning exist within the various higher education professional disciplines (Croteau et al., 2015) and in students' ICT skills (Owens & Lilly, 2017).

It is important to examine differences in ICT-integrated teaching and learning among students of various academic disciplines and to discuss, in particular, the situation for student teachers and students in education studies who, throughout their professional careers, will influence the skills development of younger generations. Since the spread of microcomputers in the 1980s, courses on instructional design and technology increasingly focus on computer-based instruction, influenced by cognitivism and constructivism that facilitated student-centered instruction (Reiser, 2001). Newly qualified teachers need to meet the realities of current classrooms (Kessels & Korthagen, 2001), populated with students living in a digitalized world (Gudmundsdottir & Hatlevik 2018), and to engage teaching pedagogies informed by student-learning approaches and digital practices (Istenič Starčič, Terlevic, Lin, & Lebeničnik 2018). Student teachers increasingly have access to digital resources, but significant diversity in teachers' competences for technology integration is apparent (Gudmundsdottira & Hatlevikb, 2018). Often, a mismatch can be identified between what is expected of newly qualified teachers and their preservice preparation (Instefjord & Munthe, 2017). In this research, we examined whether a difference is apparent in the perceptions of the learning context and the teacher-as-model among students in various higher education academic fields, ranging from education and the arts and humanities to business and law to engineering, math, and ICTs.

Purpose of the Study

The P21 discussions about 21st-century learning and innovation skills, collaboration, creativity, and skills for work with technology (Adams Becker et al., 2017) motivated our research design. This current study examined the academic learning environment in its function in preparing graduates for a working life infused with technology-driven environments. For successful digitalization of academic curricula, students' perceptions and preferences should guide the teacher's pedagogical decisions (Prosser & Trigwell, 2000). Prior research among university students and teachers identified a large gap between students' and teachers' perceptions of the students' use of technology in learning (Dahlstrom, 2015). Earlier research indicates that teachers are insufficient in serving as technology-use role models (Instefjord & Munthe, 2017) but indicates that teachers must assume responsibility as curriculum developers, not just curriculum transmitters (Bouckaert & Koos, 2017).

Based on the reviewed literature, we designed our research objectives to examine students' perception of the microlearning environment. The SQD model (synthesis of qualitative evidence; Tondeur et al., 2012, 2016) of the strategies for technology integration in teacher education informed our study. The SQD model defined factors in three levels: micro-, institutional, and system. In this study, we focused on the microlevel, which, according to Tondeur et al. (2016), consists of instructional design, authentic learning experience, reflection, feedback, collaboration, and the teacher as a role model. We drew from the SQD model in the framework of social cognitive theory, which defines learning as self-reflective and self-regulative in the process of interaction among the person, the behavior in learning situation context, and the environment (Bandura, 1986).

The SQD model (Tondeur et al., 2012, 2016) refers to teachers arranging the learning environment and functioning as role models. In establishing the learning environment, the teacher is responsible for the design of curriculum materials, creating an authentic learning experience, facilitating collaboration among students, and demonstrating technology use. In our study, we examined the students' perceptions of the learning environment by forming five research constructs: teacher's ICT integration into teaching, the requirement of ICT use within the university's learning environment, students' ICT use for collaboration, students' beliefs about ICTs, and the teacher as a role model.

The social cognitive theory informed our study by its discussion of learning complex skills, vicariously by observing the role model's components of action and behavior and "enactively" through actual performance (Bandura, 1971, 1986). According to social cognitive theory, the learning environment is influenced by a complex interplay between personal and sociocultural factors. How students construct their learning environment by selecting learning resources and how they are imposed by formal university curricula are integral parts of this complex interplay between the personal and social contexts. We examined the imposed, university-defined learning environment, known also as a guided environment, and the selected learning environment, which is chosen by students making decisions when creating their personal digital learning environments, a context also known as an unstructured environment (see also Lebeničnik & Istenič Starčič, 2018a).

New technology provides great potential for fusion among academic, professional, and personal spheres, thereby constructing a unique learning environment that combines the selected and imposed environments. In this study, we examined students' perceptions of the imposed and selected environments within the formed research construct of technology integration, the requirements within the university's learning environment, ICTs for collaboration, and the role of the teacher as a model for ICT use (see Figure 1).

Figure 1 represents our research model in concentric circles. In our study, we addressed 4C learning, innovation, and skills for work with technology, together which provide a basis for the 21st-century skills. The outside circle therefore highlights the 21st-century learning and innovation skills—which are creativity, critical thinking, communication, and collaboration—

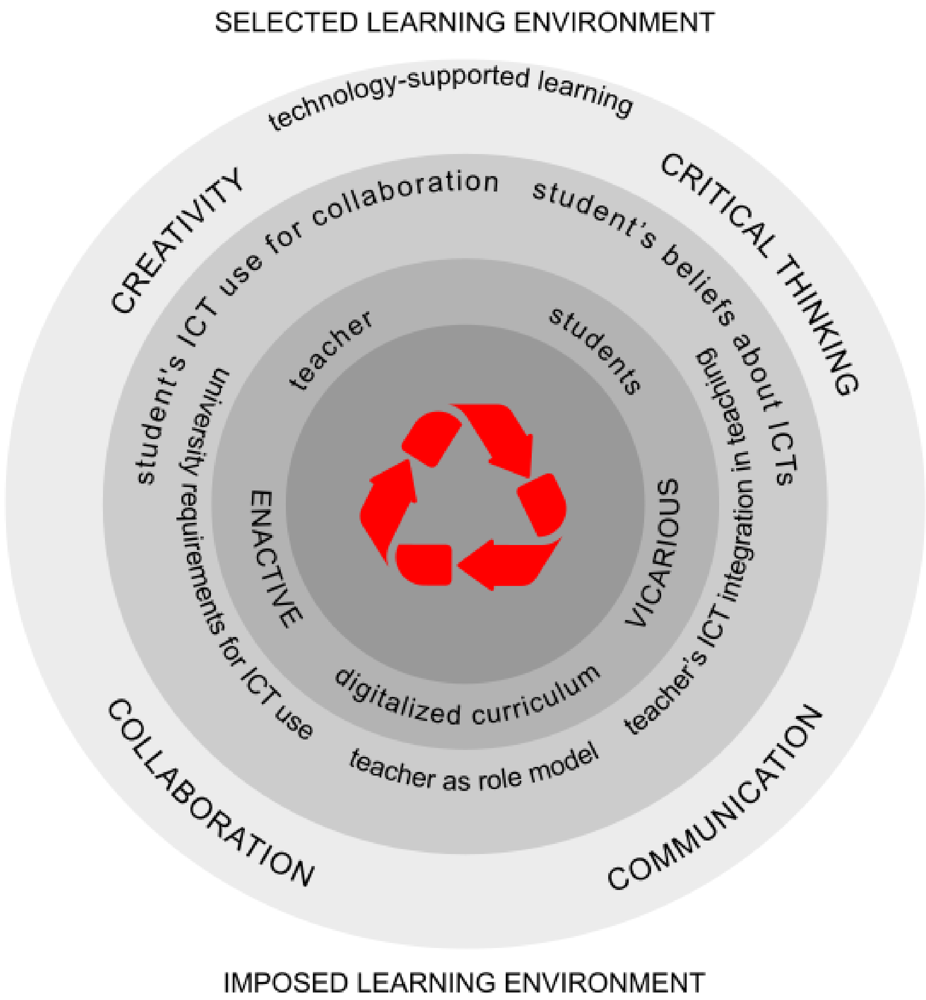

Figure 1. Students’ perception of the microlearning environment with reference to enactive and vicarious learning for 21st-Century skills development.

and skills for technology-supported learning. Inside the skills circle is a space with the components affecting students’ ICT use, which we designed as research constructs for our study: Students’ perception of the Teacher as a Role Model, the University’s Requirements for ICT Use, and the Teacher’s ICT Integration in Teaching, Students’ Beliefs about ICTs, and Students’ ICT Use for Collaboration. These are also names of the measurement scales that we designed for our study. In the inner circle, the teacher, student, and digitalized curriculum provide the basis for vicarious and enactive learning. Above the concentric circles, the selected learning environment embodies the student’s unstructured environment, whereas beneath the circles is the imposed learning environment focusing more on learning environment guided and provided by the university.

Technology Integration in the Higher Education Learning Environment

Technology integration into teaching and learning in university learning environments makes an important contribution to students’ development of competences and skills (Adams Becker et al., 2017; Jääskelä et al., 2017). This requires digital competences to be integrated across curricula at all educational levels. Three possible approaches are applicable for developing competences and skills for ICT use in the professional setting and in the civic and personal spheres of life:

1. The curricular approach involves offering specific courses in computing and information technology.
2. The cross-curricular approach integrates computing and information technology into subject-specific professional-development areas. This integrated approach provides a greater degree of application and sustainability than does the curricular.
3. The most widespread extracurricular practices are informal, self-directed learning approaches that employ online learning resources and collaboration; such informal approaches should be integrated into the formal curriculum (Adams Becker et al., 2017).

Integrating learning technology into the higher education environment, a process that requires a sharp learning curve, has slower adoption and higher rejection by faculty (Underwood & Dillon, 2011). Chandra and Mills (2015) discussed adoption strategies and noted the significant potential for merging ICTs seamlessly into education as well as niche uses of ICTs. Technologies could merge seamlessly with or transform pedagogical practices in learning environment design, within the collaboration between the teacher and students, and among students themselves (Adams Becker et al., 2017).

Digitalizing the higher education curriculum involves reflective practices in planning and designing online learning content and lesson performance (Conole et al., 2004), utilizing artificial intelligence and a variety of sources of data for tracking students' learning processes comprehensively, as well as aligning teaching strategies and feedback that affect students' learning approaches (Gašević & Siemens, 2015). Integrating contemporary technologies and artificial intelligence into education supports insights into the learning process and facilitates reflection on teachers' roles (Istenič Starčič, 2019). This perspective can challenge current beliefs on ICTs in teaching and learning, yet captures the authenticity of ICTs in students' life experiences and professional practices. Authenticity in teaching is achieved by integrating students' authentic existent ICT practices with anticipated professional ICT practices.

Students' perceptions of the higher education learning environment is critical for their selection of learning approaches and consequent academic success; these perceptions also provide essential information for teachers' planning and instructional designs (Prosser & Trigwell, 2000). Digitalized curricula require a diversity of online learning resources, activities, and student skills. However, a divide often is apparent between imposed and selected learning environments. Universities use learning management systems, which tend to be university driven, while students use social media, which are more student driven (Dabbagh & Kitsantas, 2012).

Apart from providing reading packages, students are made aware of the great variety of online resources available to them to enhance their learning; students' can select these autonomously from the course curriculum (Lebeničnik & Istenič Starčič, 2018a, 2018b). Therefore, a university's readiness for and ability to integrate a variety of digital channels to connect the imposed and selected learning environments will support the students' development of 21st-century skills. Online learning resources are beneficial for the flipped classroom model by supplementing the two integral modes of flipped learning: (a) prior classroom preparation and (b) interactive classroom work. Prior to a classroom lecture, online resources are studied at home; then, during classroom work, active learning methods are applied utilizing the online learning resources. Sun, Xie, and Anderman (2018), in their overview of the flipped classroom, highlighted the contribution of Internet-based learning (i.e., online instructional videos and text readings) versus traditional face-to-face instruction. These authors argued for self-directed preclass learning to increase the quality of students' performance in a flipped classroom and for their overall learning outcomes (Sun et al., 2018). They indicated a need for a transition from the traditional transmissive lectures to supporting self-directed preparation prior to classroom work, which also serves as a basis of knowledge and a form of interactive learning. For both preclass preparation and interactive classroom work, online learning resources could be used as a combination of the selected and imposed learning environments. A virtual extension of the physical classroom also requires university teachers to use technology to support students in developing community among themselves and providing collaborative activities online outside the classroom (Dabbagh & Kitsantas, 2012).

Appropriate instructional or institutional support within a formal curriculum where students bring their own devices (BYOD) also is an important facilitator in the formation of personal learning environments. Such processes connect learning during lectures with learning outside lectures and tutorials (Adams Becker et al., 2017), as well as reduce the intention–behavior gap in learning (Crossler, Long, Loraas, & Trinkle, 2014).

When considering the components of initial teacher education, ICT integration is critical in teaching and learning (Drent & Meelissan, 2008). Therefore, teacher education should provide authentic experiences (Reeves, Herrington, & Oliver, 2002; Tondeur et al., 2016) that expose students to a variety of teaching strategies and classroom activities (Hattie, 2009), a diversity of outcomes, and seamless integration into assessment (Reeves et al., 2002). Authentic learning experiences also require an integrated approach connecting technological, pedagogical, and content knowledge (Mishra et al., 2009) and connect the learner to the social context where the technology is applied (Istenič Starčič & Turk, 2016). As a result, in line with Tondeur's SQD model (Tondeur et al., 2012, 2016), influencing factors at the microlevel are integrated into the contexts at the institutional and system levels.

Teacher-Educator as a Role Model

Students' observation of their teacher's behavior during the learning process is an essential component of their education (Kelcherman, 2009). Concerning the inclusion of ICTs in classroom teaching, how much a teacher's behavior influences students' use of technologies for learning is uncertain. Based on a survey among preservice teachers in Flanders, Belgium, Tondeur et al. (2016) stressed that the teacher-educator as a role model in technology use is critical, as their research suggested teacher-educators seem not to provide sufficient modeling. Lai (2015) mapped teachers' behavior in technology integration, assessing also the teacher's influence on students' technology use outside the classroom. He highlighted a combination of roles the teacher plays on three levels: affection (i.e., encouragement and enhancing awareness for technology use), capacity (i.e., use recommendations and tips), and behavioral support (i.e., the teacher serves as a model for technology use). Thus the teachers' role in technology integration needs close attention. Teacher-educators perform many roles, and in technology integration, we highlight two: as a role model in ICT use with actual use behavior and as curriculum developer offering experiences concerning a digitalized curriculum (Bouckaert & Koos, 2017). Katyal and Evers (2004) confirmed the two levels of teachers' activity explicitly through instructional practice and implicitly by role modeling (see also Lai, 2015). Because technology integration requires addressing technological, pedagogical, and content knowledge (Mishra et al., 2009), role modeling requires actual use of technology in teaching and curriculum design (Tondeur et al., 2016). Student learning from observing role models or from the implicit modeling provided through the design of the curriculum is essential in preparing for technology integration (Milrad, Spector, & Davidsen, 2002) in professional contexts. Modeling also provides one of the most important sources for transmitting values and attitudes (Bandura, 1986). Teachers should introduce new technological solutions by modeling their professional use of ICTs, thus acting as role models and facilitating observational learning. Vicarious learning occurs through students observing actual performance or by symbolic models in the absence of overt performance. Such processes enhance learning better than if students have to perform every action one at a time to learn it.

The rapidly changing social context concerning technology developments and younger generations increasingly adopting new technologies into their day-to-day lives require leadership by teachers in the field. Teacher-educators increasingly are responsible for integrating technological innovations into the initial preservice curriculum development and for modeling technology integration through continual curriculum development (Bouckaert & Koos, 2017; Tondeur et al., 2016), providing authentic experiences through applying a set of strategies (Tondeur et al., 2016) that support changes at the levels of attitudes and behavior (Instefjord & Munthe, 2017). Based on Bandura's (1986) research, teacher-educators transmit values and attitudes through modeling. Thus, teachers' actions could directly inhibit or facilitate students' actions, while the teachers advance learning through modeling, that is, students develop new behaviors based on observation of their teachers' modeling (Schunk, 2012, pp. 127). By observing their teachers' interactions with technology and participating in digitalized curriculum learning activities designed by their teachers, student teachers acquire experiences in technology use that influence the development of attitudes, beliefs, and motivation for using ICTs during their initial education, which in turn encourages their future pedagogical technology integration.

Collaborative and Creative Aspects of Learning and Students' Beliefs About ICT Use

Technology-supported learning environments facilitate critical thinking, collaboration skills (Jääskelä et al., 2017), and creativity (Idris & Nor, 2010; Loveless et al., 2003; Sang et al., 2010). Such learning environments also could reduce the divide between academic and professional behaviors in real-life contexts (Istenič Starčič et al., 2018).

Collaboration is among the main affordances of ICTs (Conole & Dyke, 2004) and is essential in student-centered technology-supported learning (Means & Olson, 1997). Information sharing and networking form the basis for the information society and the networked society. Computer-supported collaborative learning, which rose in 1980s, continues to be a main trend in higher education (Adams Becker et al., 2017). Thus, the higher education classroom extends outward from the physical classroom through the spread of online resources, most of which are predominantly collaborative in nature.

Karakaya and Demirkan (2015) and Muldner and Burleson (2015) examined these collaborative digital environments as means for enhancing creativity. Creativity in learning is augmented when students are curious and excited (Torrence & Goff, 1990), and technology-supported learning increases the level of students' creativity in learning (Sang et al., 2010). Idris and Nor (2010) examined ICT integration into learning with reference to excitement, motivation, and curiosity, which enhance learning. Flexible environments, facilitated by the affordances of ICTs, also support creativity (Davies et al., 2013).

Darling-Hammond (2017) discussed teacher preparation in a 21st-century curriculum based on collaboration and interactive computer technology for meaningful learning. In teacher education and education studies, group work and collaboration with peers are essential when preparing them for technology integration in teaching (Hao & Lee, 2017: Hattie, 2009; Tondeur et al., 2016), as well as providing opportunities for engagement and reflection (Tondeur et al., 2016).

Teaching and learning should engage students in authentic technology practices such as social network practices, which parallel students’ authentic social practices (Istenič Starčič et al., 2018). Collaboration and online sharing behaviors also support vicarious learning (Bandura, 1986; Schunk, 2012), which could contribute to technology adoption (Adams Becker et al., 2017) into other spheres of their lives and enhance their beliefs about technology integrated into learning and teaching. The use of social collaboration practices among peers and other groups facilitates the formation of beliefs, which in turn, guides behavior (Ajzen, 2001).

Regarding meaningful learning, we also examined the relationship between beliefs and technology use, focusing on collaborative learning as an integral part of student-centered learning (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Means & Olson, 1997). Ertmer et al. (2012) concluded that beliefs regarding student-centered learning correspond with collaborative technology-supported learning.

Beliefs are regarded as the most influential internal factors of behavior (Ertmer et al., 2012), influencing, in the case of educational behavior, the probability of pedagogical change (Hao & Lee, 2017). Sang et al. (2010) established that attitudes toward technology in education among student teachers are the strongest predictor of future use. Preservice education could impact significantly a student’s internal factors (Paratore, O’Brien, Jiménez, Salinas, & Ly, 2016) and is therefore critical for developing future teachers’ beliefs about technology integration in teaching and learning (Drent & Meelissan, 2008). Beliefs are the mediating factor that build the framework of values embedded within the learning process and skills development. Whether or not preservice teachers integrate the value of ICTs into their beliefs will influence their prospective technology integration (Chen, 2010).

Research has demonstrated that, among university students, beliefs toward ICT use in learning is one of the main predictors for technology use (Lai, Wang, & Lei, 2012). Thus, beliefs are strong influencing factors in relation to one’s attitudes toward (Ajzen, 2001), perceived capabilities of (Bandura, 1986), and perceived characteristics of ICT in learning. Beliefs predict behavior as predisposition to respond favorably or unfavorably toward an object or objective (Ajzen, 1988). In related studies, Sang et al. (2010) identified several key research-instrument scale items for beliefs toward ICT use in education: improving learning performance, efficiency, individualization and differentiation in learning, and the level of creativity in students. Van Braak and Tearle (2007) identified three more: (a) observability, referring to ICT use allowing teachers and peers to see outcomes; (b) specificity, referring to ICTs supporting tasks that otherwise are not possible; and (c) flexibility with ICTs, providing learning activities performed with greater adaptability. In related studies, outcomes of beliefs regarding ICTs in education include ICT usage, motives toward accessing information, increased interaction, and networking and collaboration (LaRose & Eastin, 2004; Senkbeil & Ihme, 2017).

Hypotheses

As noted earlier, a digital index report on the differences across sectors and professional disciplines indicated a low ranking for the educational sector (Manyika, 2015). In higher education, a Canadian study (Croteau et al., 2015) reported disciplinary differences in ICT integration in teaching and learning. Therefore, we wanted to examine whether differences exist among several professional disciplines, ranging from education and arts and humanities to business and law and to engineering and math and ICTs. In our research, the focus is on investigating any differences between student-teachers and students in the education studies and students in other disciplines. The following hypotheses guided our research:

H1: A difference can be identified among the disciplines regarding students' perceptions of technology integration in teaching, corresponding to the frequency of ICT use by teachers.

H2: Among disciplines, differences will be apparent in students' perceptions of the technology integration requirements of the university learning environment.

H3: There is a difference among disciplines in students' perceptions of the teacher as a role model in technology integration.

H4: A difference exists among disciplines in students' perceptions of their ICT use for collaboration.

H5: Students' beliefs about ICT use will differ among the disciplines.

METHOD

Research Design, Participants, and Procedures

We designed a survey as part of a study, titled "The Online Learning Resources in Higher Education." The University of Ljubljana, Slovenia, invited us to conduct this survey as part of their "The Integration of Information and Communication Technology in Higher Education Pedagogical Process" project. For this study we developed scales to examine students' views of "the teacher as a role model for ICT use," "university requirements for ICT use," and "teacher's ICT integration in teaching."

This exploratory study allowed us to seek out possible disciplinary differences that have not been investigated extensively. The objective of our research was to identify issues that could be addressed in the future. We conducted the survey study at one university in Slovenia; however, it is the largest among four Slovene universities, with approximately 40,000 students coming from all parts of Slovenia. The university enrolls 67.3% of the Slovene student population (Republic of Slovenia, Ministry of Education, Science, and Sport, 2018).

We conducted the survey in June and July 2017, during the examination period, so we anticipated a low response rate. The university's vice-rector forwarded an e-mail from the research team inviting students to participate in an online survey on ICT use. The invitation was sent to all students enrolled that academic year, with 2,325 taking part. However, only 1,359 students provided usable responses by completing the whole survey. Completion required answering questions about technology integration in teaching, requirements for technology integration in the learning environment, and the teacher as a role model. Tables 1 and 2 present the distribution of respondents (N = 1,359).

Table 1. Survey Participant Distribution by Sex and Study Level.

		Total	
		f	***%***
Sex	Female	898	66.1
	Male	461	33.9
Study level	1st Bologna cycle	829	61.0
	2nd Bologna cycle	474	34.9
	3rd Bologna cycle	56	4.1
	Total	1,359	100.00

Note. 1st Bologna cycle = Bachelor program; 2nd Bologna cycle = Master program; 3rd Bologna cycle = Doctoral program.

Table 2. Survey Participant Distribution by Study Field.

Study field, KLASIUS-P* ACRONYM		**f**	**%**	**f **Total student population in Slovenia**
TEES	Teacher Education and Education Studies	154	11.3	7,521
AH	Arts and Humanities	206	15.2	7,299
SSBAL	Social sciences, Business, administration and law	273	20.1	22,130
NSMI	Natural sciences, mathematics, and ICTs	343	25.2	8,030
EMC	Engineering, manufacturing and construction	213	15.7	14,182
HW	Health and welfare	168	12.4	9,786
	Total	1,359	100.0	68,948

Note. *The KLASIUS-P classification is based on the similarities of subject-specific characteristics and is used for statistical and administrative purposes (Statistical Office of Republic of Slovenia, 2017). **Data about total student population in Slovenia in 2016/17 by study fields is based on data from the Statistical Office of the Republic of Slovenia (2017).

Data Analysis

We calculated the descriptive statistics for numeric variables (e.g., mean, standard deviation). Data were screened for the assumption of normality of distribution using the Shapiro-Wilk test and histograms and for the assumption of homogeneity of variance using Leven's test. We conducted a one-way analysis of variance (ANOVA) to identify whether differences between academic disciplines existed. If a one-way ANOVA was statistically significant, we additionally performed a post hoc test of multiple comparisons to establish between which study programs the differences exist. When the assumption of normality of distribution and homogeneity of variance were confirmed, and statistical significance established ($p < 0.05$), we applied the Tukey post hoc test of multiple comparisons. When the Shapiro-Wilk test and histograms identified a violation of assumptions of normality and the Leven test identified nonequal variances, we applied a nonparametric test, the Kruskal-Wallis test by ranks. In cases of significant difference between study programs identified by the Kruskal-Wallis test ($p < 0.05$), we additionally performed pairwise comparisons with Bonferroni corrections for multiple comparisons.

For estimating effect size we calculated Cohen's *d* using the means and standard deviations of each pair of groups between which significant differences were found in the post hoc testing. Effect sizes were interpreted as small ($d \geq .2$), medium ($d \geq .5$) and large ($d \geq .8$; Cohen, 1988). We also performed principal axis factoring (PAF) to establish clear, reliable factors for each category of variables and discover the latent structure of measured constructs.

Measures

Based on the SQD model (Tondeur et al., 2012, 2016) and social cognitive theory placing special emphasize on vicarious and enactive learning, we developed the following scales: Teacher as a Role Model, Teacher's ICT Integration in Teaching, and University's Requirements for ICT Use. We designed the items on the scales Teacher as a Role Model and Teacher's ICT Integration in Teaching based on Lai (2015). The Teacher's ICT Integration in Teaching referred to how often the teacher used ICTs. We drew on Lai (2015) and Dahlstrom et al. (2015) to design the items on the scale University's Requirements for ICT Use.

We performed PAF (Table 3) for the scales Teacher as a Role Model, Teacher's ICT Integration in Teaching, and University's Requirements for ICT Use. To measure frequency for Teacher's ICT Integration in Teaching and University's Requirements for ICT Use, we used an ordinal five-point Likert scale (1–*Never*, to 5–*Very often*). The ordinal five-point Likert measure (1–*Completely disagree*, to 5–*Completely agree*) was set for the Teacher as a Role Model scale.

Seven items with cross loadings were dropped (Table 3). Items with factor loadings above .350 were included (Clark & Watson, 1995) and were between .802 and .350. The rotation method was Varimax with Kaiser Normalization and converged in five iterations. We inspected scree plots for inclusion of factors in final solutions. The KMO value was 0.873, and Bartlett's sphericity test was significant ($p < 0.001$). PAF revealed three factors (Table 3). The first factor, Students' perception of Teacher as a Role Model, explained 20.5% of the variance, and the internal consistency was at a high level (Cronbach's alpha = 0.896). The second factor, Students' Perception of the University's Requirements for ICT use, explained 11.9 % of the variance and the internal consistency was at a high level (Cronbach's alpha = 0.742). The third factor, Students' Perception of Teacher's ICT integration in teaching, explained 10.1 % of the variance and the internal consistency was questionable (Cronbach's alpha = 0.609). We kept the last factor in the analysis, due to its contents, even if its alpha is questionable.

To examine collaborative and creative aspects of learning and students' beliefs about ICT use, two scales were used, Student's Beliefs About ICTs and Students' ICT Use. We designed the scale Student's Beliefs about ICTs with a five-point Likert scale (1–*Completely disagree*, to 5–*Completely agree*) in the framework of social cognitive theory and based on items from scales designed by Dahlstrom (2015), McGraw-Hill (2017), Hakkarainen et al. (2000), Lai et al. (2012),

Table 3. Factorial Structure of Teacher as a Role Model, University's Requirements for ICT Use, Teacher's ICT Integration in Teaching.

Factor	Items	1	2	3
Teacher as a Role Model	I look to faculty for how to resolve problems that may occur during ICT use.	**.802**	.037	.119
	Faculty use innovative technological solutions.	**.757**	.110	.234
	Faculty show enthusiasm for using technological solutions.	**.732**	.094	.182
	Faculty are successful in using ICT for teaching.	**.709**	.100	.214
	Faculty are at least as competent as I am in using ICTs.	**.674**	.033	.127
University's Requirements for ICT Use	I am required to use ICTs for data analysis.	.169	**.738**	.213
	I am required to use ICTs for computer-supported collaborative learning.	.123	**.719**	.221
	I am required to use ICTs for independent study.	.192	**.609**	.260
	I am required to use ICTs for which I do not get adequate training.	-.065	**.387**	-.003
Teacher's ICT Integration in Teaching	ICT use for outside classroom lectures and tutorials for students' activities (e.g., computer-supported collaborative learning).	.078	.098	**.599**
	ICT use for feedback and assessment.	.112	.056	**.511**
	ICT use during classroom lectures and tutorials for students' activities (e. g., computer-supported collaborative learning).	.096	.149	**.452**
	ICT use outside classroom lectures for learning content prior to organized class lectures.	.164	.096	**.373**
	Enhancing bring your own device (BYOD) during organized classroom activities.	.134	.096	**.350**
	Cronbach's alpha	0.896	0.742	0.609
	% of variance	20.51	11.90	10.10
	Number of items	5	4	5

Note. Extraction method: Principal axis factoring; Rotation method: Varimax with Kaiser Normalization. Rotation converged in five iterations.

Sang et al. (2010), van Braak & Tearle (2007), LaRose & Eastin (2004); Senkbeil & Ihme, (2017). The scale Students' ICT Use, with an ordinal five-point Likert scale measuring frequency (1–*Never*, to 5–*Very often*), drew on the work of Laurillard's classification (2002), Churchill (2007), and Dabbagh and Reo (2011).

We performed PAF (Table 4) for the two scales, Student's Beliefs about ICTs and Students' ICT Use. Eight items with cross loadings were dropped. Items with factor loadings above 0.35 were included (Clark & Watson, 1995) and were between .703 and .350. Rotation method was Varimax with Kaiser Normalization and converged in 11 iterations. We inspected scree plots for inclusion of factors in final solutions. The KMO value was 0.953, and Bartlett's sphericity test was significant ($p < 0.001$).

PAF revealed three factors (see Table 4). The first factor, Students' ICT use, explained 13.8% of the variance, and the internal consistency was at a good level (Cronbach's alpha = 0.896). The second factor, Student's Beliefs about ICTs, explained 13.5 % of the variance, and the internal consistency was at a high level (Cronbach's alpha = 0.900). The third factor, ICT use for collaboration, explained 10.3 % of the variance, and the internal consistency was at a high level (Cronbach's alpha = 0.831).

Table 4. Factorial Structure of Student's ICT Use, Student's Beliefs about ICT and Student's ICT Use for Collaboration.

Factor	Items	1	2	3
Student's ICT use	I watch educational videos (e.g., video lectures).	**.635**	.220	.088
	I use online learning content designed by fellow users of social network sites.	**.613**	.297	.151
	I use online simulations.	**.590**	.232	.188
	I use online tutorials.	**.566**	.232	.167
	I visit Web portals with educational content from my study field.	**.565**	.181	.284
	I use Web encyclopedias.	**.563**	.221	.100
	I read weblogs with content from my study area (e.g., blogs, social networks).	**.532**	.229	.383
	I bookmark websites with educational content from my study field (e.g., pinterest.com, bookmark in browsers).	**.501**	.138	.276
	I network on social media (e.g., following or adding people, subscribing to channels) with the intention to get access to educational content from my study field.	**.488**	.167	.368
	I subscribe to digital newsletters and notifications from websites with educational content.	**.475**	.054	.403
	I use social bookmarking sites (e.g., reddit.com, pinterest.com, del.icio.us) to learn from other users about relevant online resources from my study field.	**.456**	.160	.286
	I use information generated from communication between online users (e.g., forums, Q&A websites, comments on websites) while learning.	**.446**	.179	.393
	I use online databases with scientific and professional articles while learning.	**.437**	.115	.115
	I use online pictures (e.g., mind maps, graphics) while learning.	**.432**	.289	.202
	I use Web search engines while learning.	**.418**	.322	.039
	I use Web applications for knowledge self-assessment (e.g., quizzes).	**.356**	.162	.306
	I use online dictionaries/translation applications.	**.350**	.144	.148
Student's beliefs about ICTs	Using ICTs for learning allows me to customize the learning process to my needs.	.231	**.703**	.098
	Learning with ICTs is more fun than traditional learning.	.200	**.669**	.102
	I have better grades because of use of ICTs for learning.	.197	**.636**	.140
	ICT use allows me to be more creative in learning.	.230	**.630**	.117
	When I use ICTs, I am more curious during learning.	.246	**.613**	.096
	ICT use supports me in better collaboration with others.	.090	**.565**	.316
	ICTs allows me to learn anywhere.	.233	**.562**	.087
	Others (e.g., professors, colleagues) can see positive results when I use ICTs for learning.	.151	**.527**	.276
	Information gathered online is better than information from other sources.	.182	**.524**	.181
	On the Web, I have access to learning information I could not get anywhere else.	.220	**.518**	.021
	ICT use offers me a feeling of belonging to a group.	-.051	**.506**	.429
	Using the Web for learning, I can get access to more information than with any other source (e.g., books, professors).	.282	**.495**	.055
	Using ICTs for learning allows me to get to know other people better.	.145	**.466**	.356
	Using ICTs allows me better personal interaction with academic staff.	.395	**.444**	.075
	On the Web, I can better follow trends in my study field.	.395	**.444**	.075

Table 4. Factorial Structure of Student's ICT use, Student's beliefs about ICT and Student's ICT use for collaboration (continued)

Student's ICT use for collaboration	I seek help online if I have a problem.	.149	.148	**.632**
	I share information related to my courses on social media sites.	.307	.042	**.584**
	I participate in social network sites discussions from my study fields.	.279	.106	**.539**
	I follow the educational content suggested by computer recommendation system (e.g., on multimedia platforms, social networks, online news).	.440	.240	**.506**
	I participate actively in online communities in my study field where I know the majority of participants.	.051	.187	**.499**
	I use synchronous communication e-tools for communicating with other students while learning (e.g., Skype, Facebook Messages, gTalk, Viber).	.115	.226	**.461**
	I post blogs on the Web with content from my study field (e.g., long posts on social networks, a stand-alone blog, use of blog platforms, online weblog writing).	.357	.012	**.454**
	I co-create documents for my course learning (e.g., Google docs, Wiki).	.358	.144	**.434**
	I use news aggregators (RSS feed, e.g., feedly.com).	.328	.085	**.426**
	I share my own files for learning with others (e.g., Google Drive, Dropbox).	.273	.167	**.420**
	Cronbach's alpha	0.896	0.900	0.831
	% of variance	13.87	13.50	10.30
	Number of items	16	15	10

Note. Extraction method: principal axis factoring; Rotation method: Varimax with Kaiser Normalization. Rotation converged in 11 iterations.

RESULTS

A Difference Among Disciplines in Students' Perception of Teacher's ICT Integration in Teaching Corresponding to the Frequency of ICT Use by Teachers

Students assessed the frequency of occurrence of items in teaching on an interval scale (1–*Never*, to 5–*Very frequently*). Statistically significant differences were identified between the various disciplines in three items; the data partly confirmed H1. Post hoc tests identified pairwise difference with small effect size. No statistically significant difference was found in two items (Table 5).

Kruskal-Wallis testing identified significant differences between disciplines for ICT use for classroom activities, $\chi^2(5) = 19.150$, $p = .002$, ICT use for learning content prior to lectures, $\chi^2(5) = 17.938$, $p = 0.00$, and feedback and assessment, $\chi^2(5) = 13.051$, $p = 0.023$.

Compared to those in other disciplines, TEES students' means were lowest only in two items of five. The lowest were in BYOD ($M = 2.52$, $SD = 1.08$) and feedback and assessment ($M = 2.56$, $SD = 1.03$). The balance of the items were ICT use outside classroom lectures and tutorials for student activities ($M = 2.81$, $SD = 1.13$) and for learning content prior to lectures ($M = 2.84$, $SD = 1.11$). TEES students had high means relative to others in ICT use for activities during lectures ($M = 3.25$, $SD = 1.98$), differing significantly from students in HW ($M = 2.77$, $SD = 1.02$).

Table 5. ANOVA and Post Hoc Test Results for Teacher's ICT Integration in Teaching Corresponding to the Frequency of ICT Use by Teachers.

Items	**Study field–KLASIUS-P**	***M***	***SD***	**Between-group difference (Post hoc test /pairwise comparison)**
UT1. Enhancing bring your own device (BYOD) during classroom activities.	TEES	2.52	1.08	n.s.
	AH	3.06	1.27	
	SSBAL	2.79	0.95	
$F(5) = 9.699$, $\mathbf{p = 0.084}$	NSMI	2.86	1.11	
	EMC	2.80	1.10	
	HW	2.53	0.86	
	Total	2.76	1.07	
UT2. ICT use during classroom lectures and tutorials for students' activities (e.g., computer-supported collaborative learning).	TEES	3.25	0.98	HW < TEES ($\mathbf{p = 0.013}$, $d = 0.47$),
	AH	3.00	1.00	HW < SSBAL ($\mathbf{p = 0.002}$, $d = 0.44$)
	SSBAL	3.24	1.08	
	NSMI	3.03	1.15	
$\chi^2 = 19.150$, $\mathbf{p = 0.002}$	EMC	2.99	1.06	
	HW	2.77	1.02	
	Total	3.04	1.07	
UT3. ICT use outside classroom lectures and tutorials for students'' activities (e.g., computer-supported collaborative learning).	TEES	2.81	1.13	n.s
	AH	2.96	1.04	
	SSBAL	3.05	1.12	
	NSMI	3.07	1.17	
$F(5) = 7.890$, $p = 0.162$	EMC	3.08	1.05	
	HW	2.72	1.06	
	Total	2.97	1.10	
UT4. ICT use outside classroom lectures for learning content prior to organized class lectures.	TEES	2.84	1.11	HW < SSBAL ($\mathbf{p = 0.006}$, $d = 0.47$),
	AH	3.11	1.00	HW < ECM ($\mathbf{p = 0.047}$, $d = 0.46$)
	SSBAL	3.27	1.14	
$\chi^2 = 17.938$, $\mathbf{p = 0.003}$	NSMI	3.10	1.12	
	EMC	3.25	1.11	
	HW	2.76	1.00	
	Total	3.09	1.09	
UT5. ICT use for feedback and assessment.	TEES	2.56	1.03	n.s
	AH	2.69	1.17	
	SSBAL	2.93	1.21	
$\chi^2 = 13.051$, $\mathbf{p = 0.023}$	NSMI	3.07	1.20	n.s
	EMC	3.01	1.09	
	HW	2.68	0.89	
	Total	2.89	1.13	

Note. UT–University teaching; TEES–Teacher Education and Education Studies; AH–Arts and Humanities; SSBAL–Social sciences, Business, administration and law; NSMI–Natural sciences, mathematics, and ICTs; EMC–Engineering, manufacturing and construction; HW–Health and welfare.
$p < .05$ is in bold; n.s.–nonsignificant,

Post hoc testing indicated HW students (*M* = 2.77, *SD* = 1.02) use ICTs less frequently during classroom lectures and as tutorials for student activities (e.g., computer-supported collaborative learning) than do TEES (*M* = 3.25, *SD* = 1.98) and SSBAL (*M* = 3.24, *SD* = 1.08) students. ICT use outside classroom lectures for learning content prior to organized class lectures was significantly less frequent for HW students (*M* = 2.76, *SD* = 1.00) than for SSBAL (*M* = 3.27, *SD* = 1.14) and EMC (*M* = 3.25, *SD* = 1.11) students.

There was a significant difference in ICT use for feedback and assessment; however, post hoc testing did not identify significant differences between groups. No significant differences were found in BYOD and ICT use outside classroom lectures and tutorials for student activities.

A Difference Among Disciplines in Students' Perception of University's Requirements for ICT Use

Students assessed the frequency of items in teaching and learning on an interval scale (1–*Never*, to 5–*Very frequently*). A statistically significant difference between the disciplines is apparent in all four scale items, thereby confirming H2 (Table 6). Post hoc tests identifying pairwise difference with small effect size in almost all cases. The pairwise difference with medium effect size was identified in the "I am required to use ICTs for data analysis" between AH and SSBAL (d = 0.64) and between AH and NSMI (d = 0.69).

TEES students had higher means (*M* = 3.18, *SD* = 1.25) for the item "I am required to use ICT for independent study," whereas we found a significant difference between groups, $\chi^2(5) = 16.302$, $p = 0.006$. Post hoc testing indicated that AH students (*M* = 2.77, *SD* = 1.23) use ICTs significantly less often for independent study than do students of TEES (*M* = 3.18, *SD* = 1.25) and NSMI (*M* = 3.14, *SD* = 1.20).

TEES students also had higher means (*M* = 2.17, *SD* = 1.05) for "I am required to use ICT for which I do not get adequate training," and there was a significant difference between groups, $\chi^2(5) = 21.142$, $p = 0.001$. Post hoc testing indicated AH students (*M* = 1.88, *SD* = 1.11) are required to use technology for which they do not get adequate training significantly less frequently than are students of TEES (*M* = 2.17, *SD* = 1.05) and EMC (*M* = 2.21, *SD* = 1.13).

TEES students (*M* = 2.78, *SD* = 1.19) also had the second highest mean in "I am required to use ICT for computer supported collaborative learning;" a significant difference between groups also was found, $\chi^2(5) = 57.192$, $p = 0.000$. Post hoc testing indicated AH students (*M* = 2.15, *SD* = 1.10) use technology for collaborative learning less frequently than do students of TEES (*M* = 2.78, *SD* = 1.19), EMC (*M* = 2.39, *SD* = 1.15), HW (*M* = 2.60, *SD* = 1.19), NSMI (*M* = 2.66, *SD* = 1.23), and SSBAL (*M* = 2.93, *SD* = 1.25). Post hoc testing also indicated that EMC students (*M* = 2.39, *SD* = 1.15) use technology for collaborative learning less frequently than do students of TEES (*M* = 2.78, *SD* = 1.19) and SSBAL (*M* = 2.93, *SD* = 1.25).

Post hoc testing indicated a significant difference for "I am required to use ICT for data analysis," χ^2 (5) = 71.728 $p = 0.000$. Post hoc testing indicated AH students (*M* = 2.49, *SD* = 1.19) use data analysis less frequently than do students of TEES (*M* = 3.03, *SD* = 1.11), EMC (*M* = 2.89, *SD* = 1.19), HW (*M* = 2.95, *SD* = 1.14), SSBAL (*M* = 3.26, *SD* = 1.21), NSMI (*M* = 3.32, *SD* = 1.21).

Post hoc testing indicated EMC students (*M* = 2.89, *SD* = 1.19) are using data analysis less frequently than are students of SSBAL (*M* = 3.26, *SD* = 1.21) and NSMI (*M* = 3.32, *SD* = 1.21). Post hoc testing also revealed that HW students (*M* = 2.95, *SD* = 1.14) use data analysis less frequently than do NSMI (*M* = 3.32, *SD* = 1.21) students.

Table 6. ANOVA and Post Hoc Test Results for in Students' Perception of University's Requirements for ICT Use.

Items	Study field - KLASIUS-P	*M*	*SD*	Between-group difference (Post hoc test /pairwise comparison)
UR1. I am required to use ICTs for which I do not get adequate training.	TEES	2.17	1.05	AH < TEES (***p* = 0.018**, *d* = 0.26),
	AH	1.88	1.11	AH < ECM (***p* = 0.005**, *d* = 0.29)
	SSBAL	1.93	1.02	
χ^2 = 21.142, ***p* = 0.001**	NSMI	2.04	1.07	
	EMC	2.21	1.13	
	HW	1.88	0.96	
	Total	2.01	1.06	
UR2. I am required to use ICTs for computer-supported collaborative learning.	TEES	2.78	1.19	AH < TEES (***p* = 0.001**, *d* = 0.02)
	AH	2.15	1.10	AH < HW (***p* = 0.005**, *d* = 0.21)
	SSBAL	2.93	1.25	AH < NSMI (***p* = 0.001**, *d* = 0.23)
	NSMI	2.66	1.23	AH < SSBAL (***p* = 0.001**, *d* = 0.36)
χ^2 = 57.192, ***p* = 0.000**	EMC	2.39	1.15	ECM < TEES (***p* = 0.044**, *d* = 0.33)
	HW	2.60	1.19	ECM < SSBAL (***p* = 0.001**, *d* = 0.45)
	Total	2.59	1.21	
UR3. I am required to use ICTs for data analysis.	TEES	3.03	1.11	AH < TEES (***p* = 0.001**, *d* = 0.46)
	AH	2.49	1.19	AH < EMC (***p* = 0.008**, *d* = 0.33)
	SSBAL	3.26	1.21	AH < HW (***p* = 0.006**, *d* = 0.39)
χ^2 = 71.728, ***p* = 0.000**	NSMI	3.32	1.21	AH < SSBAL (***p* = 0.001**, *d* = 0.64)
	EMC	2.89	1.19	AH < NSMI (***p* = 0.001**, *d* = 0.69)
	HW	2.95	1.14	EMC < SSBAL (*p* **= 0.019**, *d* = 0.31)
	Total	3.04	1.22	EMC < NSMI (*p* **= 0.002**, *d* = 0.35)
				HW < NSMI (***p* = 0.018**, *d* = 0.31)
UR4. I am required to use ICTs for independent study.	TEES	3.18	1.25	AH < TEES (***p* = 0.041**, *d* = 0.33)
	AH	2.77	1.23	AH < NSMI (***p* = 0.013**, *d* = 0.30)
	SSBAL	3.06	1.22	
χ^2 = 16.302, ***p* = 0.006**	NSMI	3.14	1.20	
	EMC	2.90	1.20	
	HW	3.06	1.23	
	Total	3.01	1.23	

Note. UR–University Requirements; TEES–Teacher Education and Education Studies; AH–Arts and Humanities; SSBAL–Social sciences, Business, administration and law; NSMI–Natural sciences, mathematics, and ICTs; EMC–Engineering, manufacturing and construction; HW–Health and welfare.
$p < .05$ is in bold; n.s.–nonsignificant.

A Difference Among Disciplines in Students' Perception of Teacher as a Role Model

Students marked their agreement with statements on a five-point Likert scale (1–*Totally disagree to* 5–*Totally agree*). We found a statistically significant difference between the various disciplines in all scale items and H3 therefore is confirmed (Table 7). Post hoc tests identifying pairwise difference with small effect size in all items.

On average, students in total gave negative to neutral values for teachers as role models in ICT use ($2.55 \leq M \geq 3.30$). The highest value was for "Faculty is successful in using ICT for

Table 7. ANOVA and Post Hoc Test Results for Students' Perception of Teacher as a Role-Model.

Items	**Study field KLASIUS-P**	***M***	***SD***	**Between-group difference (Post hoc test /pairwise comparison)**
TM1. Faculty is successful in using ICTs for teaching.	TEES	3.37	0.98	NSMI > HW (***p* = 0.011**, *d* = 0.30)
	AH	3.20	0.99	
	SSBAL	3.35	1.00	
	NSMI	3.43	0.96	
F(5) = 3.165, ***p* = 0.008**	EMC	3.24	1.02	
	HW	3.12	1.06	
	Total	3.30	1.00	
TM2. Faculty uses innovative technological solutions.	TEES	2.80	1.02	NSMI > TEES (***p* = 0.028**, *d* = 0.29)
	AH	2.78	0.97	NSMI > AH (***p* = 0.007**, *d* = 0.31)
	SSBAL	3.02	1.08	NSMI > HW (***p* = 0.044**, *d* = 0.26)
	NSMI	3.10	1.03	
F(5) = 4.373, ***p* = 0.001**	EMC	3.04	1.00	
	HW	2.82	1.05	
	Total	2.96	1.03	
TM3. I look to faculty for how to resolve problems that may occur during ICT use.	TEES	2.44	0.96	HW < SSBAL (***p* = 0.050**, *d* = 0.27)
	AH	2.44	0.94	HW < EMC (***p* = 0.007**, *d* = 0.36)
	SSBAL	2.56	1.11	HW < NSMI (***p* = 0.001**, *d* = 0.41)
	NSMI	2.70	1.11	
χ^2 = 24.109, ***p* = 0.000**	EMC	2.63	1.00	
	HW	2.27	0.96	
	Total	2.55	1.04	
TM4. Faculty show enthusiasm for using technological solutions.	TEES	2.63	1.04	NSMI > TEES (***p* = 0.002**, *d* = 0.36)
	AH	2.73	1.02	NSMI > AH (***p* = 0.028**, *d* = 0.27)
	SSBAL	2.75	1.12	NSMI > SSBAL (***p* = 0.031**, *d* = 0.25)
	NSMI	3.02	1.12	TEES < ECM (***p* = 0.033**, *d* = 0.32)
F(5) = 5.707, ***p* = 0.000**	EMC	2.97	1.08	
	HW	2.63	1.08	
	Total	2.82	1.09	
TM5. Faculty is at least as competent as I am in using ICTs.	TEES	3.05	1.09	NSMI > AH (p **= 0. 001**, *d* = 0.41)
	AH	2.82	1.03	NSMI > SSBAL (***p* = 0.002**, *d* = 0.29)
	SSBAL	2.93	1.12	NSMI > HW (***p* = 0. 001**, *d* = 0.44)
	NSMI	3.26	1.11	HW < EMC (***p* = 0.047**, *d* = 0.30)
F(5) = 7.299, ***p* = 0.000**	EMC	3.09	1.04	
	HW	2.77	1.08	
	Total	3.01	1.10	

Note. TM-Teacher-Model; TEES–Teacher Education and Education Studies; AH–Arts and Humanities; SSBAL–Social sciences, Business, administration and law; NSMI–Natural sciences, mathematics, and ICTs; EMC–Engineering, manufacturing and construction; HW–Health and welfare. *p* < .05 is in bold; n.s.–nonsignificant;

teaching" (M = 3.30, SD = 1.00), and the lowest was "I look to faculty for how to resolve problems that may occur during ICT use" (M = 2.55, SD = 1.04).

TEES students had lower means in most items relative to students in other disciplines. In one item, however, TEES students' mean was among the highest—"Faculty is successful in using ICT for teaching"—although in this item, TEES students were not significantly different from students of other disciplines.

There was a statistically significant difference for "Faculty is successful in using ICT for teaching," as determined by one-way ANOVA, $F(5) = 3.165$, $p = 0.008$. Post hoc testing revealed that NSMI students (M = 3.43, SD = 0.96) more strongly agreed that faculty is successful in using ICTs for teaching than did HW students (M = 3.12, SD = 1.06).

A one-way ANOVA determined a statistically significant difference between groups for "Faculty use innovative technological solutions," $F(5) = 4.373$, $p = 0.001$. Post hoc testing of students of different study programs revealed that students of NSMI (M = 3.10, SD = 1.03) agreed less strongly that faculty use innovative technological solutions than did students in TEES (M = 2.80, SD = 1.02), AH (M = 2.78, SD = 0.97), and HW (M = 2.82, SD = 1.05). However, HW students (M = 2.82, SD = 1.05) agreed less strongly with this statement than did EMC students (M = 3.04, SD = 1.00).

Kruskal-Wallis tests identified a difference between groups for "I look to faculty for how to resolve problems that may occur during ICT use, $\chi^2(5) = 24.109$, $p = 0.000$. Post hoc testing indicated that HW students (M = 2.27, SD = 0.96) agreed less strongly with this statement than did SSBAL (M = 2.56, SD = 1.11), EMC (M = 2.63, SD = 1.00), and NSMI (M = 2.70, SD = 1.11) students.

Difference between groups for "Faculty show enthusiasm for using technological solutions" was statistically significant, as determined by one-way ANOVA, $F(5) = 5.707$, $p = 0.000$). Post hoc testing indicated NSMI students (M = 3.02, SD = 1.12) agreed more strongly with this statement than did TEES (M = 2.63, SD = 1.04), AH (M = 2.73, SD = 1.02), SSBAL (M = 2.75, SD = 1.12), and HW (M = 2.63, SD = 1.08) students. There was also a statistically significant difference between students of TEES (M = 2.63, SD = 1.04) and EMC (M = 2.97, SD = 1.08).

The same was true between groups for "Faculty is at least as competent as I am in using ICTs," as determined by a one-way ANOVA, $F(5) = 7.299$, $p = 0.000$). Post hoc testing revealed that students of NSMI (M = 3.26, SD = 1.11) agreed more strongly with this statement than did students of AH (M = 2.82, SD = 1.03), SSBAL (M = 2.93, SD = 1.12), or HW (M = 2.77, SD = 1.08). There was also a statistically significant difference between HW (M = 2.77, SD = 1.08) and EMC (M = 3.09, SD = 1.04) students.

A Difference Among Disciplines in Students' ICT Use for Collaboration

Students assessed the frequency of items on an interval scale (1–*Never*, to 5–*Very frequently*). A statistically significant difference between different disciplines was found in four scale items. In six, there was no statistically significant difference, and H4 therefore is partly confirmed (Table 8). Post hoc tests identifying pairwise difference with small effect size in item 5. In item one, there was no effect between NSMI and SSBAL (d = 0.19), in item 2, there was no effect between NSMI and SSBAL (d = 0.15) and in item 5, there was no effect between NSMI and TEES (d = 0.17).

Table 8. ANOVA and Post Hoc Test Results for Students' ICT Use for Collaboration.

Items	Study field - KLASIUS-P	*M*	*SD*	Between-group difference (Post hoc test /pairwise comparison)
C1. I seek help online if I have a problem.	TEES	2.55	1.25	NSMI < SSBAL (**p = 0.027**, d = 0.19)
	AH	2.73	1.34	
	SSBAL	2.80	1.24	
$\chi^2 = 12.367$, $\boldsymbol{p = 0.030}$	NSMI	2.55	1.36	
	EMC	2.71	1.22	
	HW	2.61	1.30	
	Total	2.66	1.29	
C2. I share information related to my courses on social media sites.	TEES	2.11	1.15	NSMI < SSBAL (***p* = 0.041**, d = 0.15)
	AH	2.21	1.19	
	SSBAL	2.23	1.20	
$\chi^2 = 14.177$, $\boldsymbol{p = 0.015}$	NSMI	2.04	1.20	
	EMC	2.04	1.14	
	HW	2.19	1.20	
	Total	2.13	1.18	
C3. I participate in social network sites discussions from my study field.	TEES	2.09	1.23	n.s
	AH	2.20	1.18	
	SSBAL	2.28	1.19	
	NSMI	2.23	1.28	
$F(5) = 5.160$, $p = 0.397$	EMC	2.22	1.30	
	HW	2.17	1.14	
	Total	2.21	1.22	
C4. I follow the educational content suggested by computer recommendation systems (e.g., on multimedia platforms, social networks, online news).	TEES	2.11	1.18	n.s
	AH	2.28	1.12	
	SSBAL	2.38	1.12	
	NSMI	2.26	1.36	
	EMC	2.17	1.18	
$\chi^2 = 8.333$, $p = 0.139$	HW	2.21	1.08	
	Total	2.25	1.11	
C5. I participate actively in online communities in my study field where I know the majority of participants.	TEES	3.70	1.41	AH < TEES (***p* = 0.033**, *d* = 0.24)
	AH	3.36	1.41	SSBAL < TEES (***p* = 0. 036**, *d* = 0.25)
	SSBAL	3.34	1.37	NSMI < TEES (***p* = 0.027**, *d* = 0.17)
	NSMI	3.46	1.36	
$\chi^2 = 18.089$, $\boldsymbol{p = 0.003}$	EMC	3.46	1.30	
	HW	3.70	1.28	
	Total	3.49	1.36	
C6. I use synchronous communication e-tools for communicating with other students while learning (e.g., Skype, Facebook Messages, gTalk, Viber).	TEES	3.46	1.78	n.s
	AH	3.23	1.37	
	SSBAL	3.53	1.76	
	NSMI	3.40	1.94	
	EMC	3.34	1.82	
	HW	3.60	1.47	
$\chi^2 = 10.077$, $p = 0.073$	**Total**	3.44	1.34	

Table 8. ANOVA and Post Hoc Test Results for Students' ICT Use for Collaboration (continued)

C7. I post blogs on the Web with content from my study field (e.g., long posts on social networks, a stand-alone blog, use of blog platforms, online weblog writing).	TEES	1.42	.72	n.s
	AH	1.64	1.11	
	SSBAL	1.57	0.95	
	NSMI	1.49	0.86	
	EMC	1.48	0.78	
	HW	1.48	0.74	
χ^2 = 7.144, *p* = 0.210	**Total**	1.52	0.94	
C8. I co-create documents for my course learning (e.g., Google Docs, Wiki).	TEES	2.51	1.36	ECM < SSBAL (***p* = 0.001**, *d* = 0.30)
	AH	2.59	1.37	NSMI < SSBAL (***p* = 0.039**, *d* = 0.21)
	SSBAL	2.92	1.44	
	NSMI	2.61	1.39	
χ^2 = 19.195, ***p* = 0.002**	EMC	2.49	1.34	
	HW	2.86	1.39	
	Total	2.64	1.39	
C9. I use news aggregators (RSS feed, e.g., feedly.com).	TEES	1.31	0.65	n.s
	AH	1.41	0.66	
χ^2 = 10.738, *p* = 0.057	SSBAL	1.43	0.69	
	NSMI	1.42	0.83	
	EMC	1.42	0.63	
	HW	1.27	0.42	
	Total	1.39	0.82	
C10. I share my own files for learning with others (e.g., Google Drive, Dropbox).	TEES	3.39	1.30	n.s
	AH	3.11	1.34	
	SSBAL	3.31	1.31	
	NSMI	3.23	1.30	
F(5) 10.435, *p* = 0.064	EMC	3.41	1.26	
	HW	3.23	1.23	
	Total	3.27	1.30	

Note. C–Collaboration; TEES–Teacher Education and Education Studies; AH–Arts and Humanities; SSBAL–Social sciences, Business, administration and law; NSMI–Natural sciences, mathematics, and ICTs; EMC–Engineering, manufacturing and construction; HW–Health and welfare.
p < .05 is in bold; n.s.–nonsignificant;

TEES students had lower means relative to students of other disciplines only in 4 items of 10. The highest mean for TEES students was for "I participate actively in an online community of my study field where I know the majority of participants." TEES students also had a high mean for "I use computer-supported collaborative learning" and for "I share my own files for learning with others."

Kruskal-Wallis testing indicated significant differences for participating in online communities where participants are known, $\chi^2(5) = 18.089$, $p = 0.003$. Post hoc testing indicated AH ($M = 3.36$, $SD = 1.41$), SSBAL ($M = 3.34$, $SD = 1.37$), and NSMI ($M = 3.46$, $SD = 1.36$) students participated less frequently in online communities than did TEES students ($M = 3.70$, $SD = 1.41$).

Further, Kruskal-Wallis testing indicated significant differences for co-creating documents for course learning, $\chi^2(5) = 19.195$, $p = 0.002$. Post hoc testing indicated EMC students (M =

2.49, *SD* = 1.34) co-created groups less frequently than did students of SSBAL (*M* = 2.92, *SD* = 1.44). Post hoc testing also indicated NSMI students (*M* = 2.61, *SD* = 1.39) co-created groups less frequently than did SSBAL students (*M* = 2.92, *SD* = 1.44).

Kruskal-Wallis testing indicated significant differences for "I seek help online if I have a problem," $\chi^2(5) = 12.367$, $p = 0.030$. In this area, NSMI students (*M* = 2.55, *SD* = 1.36) revealed they seek help less frequently than do SSBAL students (*M* = 1.24, *SD* = 2.80).

Kruskal-Wallis testing indicated significant differences for "I share information related to my courses on social media sites" $\chi^2(5) = 14.177$, $p = 0.015$). NSMI students (*M* = 2.04, *SD* = 1.20) share information less frequently than do SSBAL students (*M* = 2.23, *SD* = 1.20). We found no difference in the following items: "Participating in SNS discussions in my study discipline" and "Sharing own files for learning."

A Difference Among Disciplines in Student's Beliefs About ICT Use

Students marked their agreement with statements on a Likert scale (1–*Totally disagree to* 5–*Totally agree*). We found a statistically significant difference between study disciplines in eight items (Table 9). In seven items, there were no differences, therefore confirming H5 partly. In 9 items of 15, TEES students had lower means than did students of other disciplines. Post hoc tests identifying pairwise difference with small effect size in majority of items. The pairwise difference with medium effect size was identified in the "Learning with ICTs is more fun than traditional learning." between TEES and SSBAL (*d* = 0.66) and between AH and SSBAL (*d* = 0.55), EMC and SSBAL (*d* = 0.77). The pairwise difference with medium effect size was identified in the "Information gathered online is better than information from other sources" between AH and HW (*d* = 0.67) and between AH and SSBAL (*d* = 0.55). In two items there was no effect, in item 5, between AH and HW (d = 0.18), and in item 13, between NSMI and SSBAL (d = 0.17).

Kruskal-Wallis testing indicated significant differences for the belief "Learning with ICT is more fun than traditional learning," $\chi^2(5) = 20.880$, $p = 0.001$. Post hoc testing revealed TEES students (*M* = 3.10, *SD* = 1.10) believed this more strongly than did SSBAL students (*M* = 2.36, *SD* = 1.13) but significantly more weakly than did HW students (*M* = 3.41, *SD* = 1.29). Post hoc testing revealed that AH students (*M* = 3.03, *SD* = 1.30) and EMC students (*M* = 3.17, *SD* = 0.96) also believed this more strongly than did SSBAL students (*M* = 2.36, *SD* = 1.13). Additionally, AH (*M* = 3.03, *SD* = 1.30), EMC (*M* = 3.17, *SD* = 0.96), and NSMI (*M* = 3.22, *SD* = 1.21) students believed this more weakly than did HW students (*M* = 3.41, *SD* = 1.29).

There was a statistically significant difference between groups as determined by one-way ANOVA for "I have better grades because of use of ICTs for learning," $F(5) = 21.137$, $p = 0.001$. Post hoc testing identified that TEES students believed this less strongly (*M* = 2.84, *SD* = 1.12) than did HW students (*M* = 3.10, *SD* = 1.07), EMC students (*M* = 3.12, *SD* = 1.13), SSBAL students (*M* = 3.17, *SD* = 1.01), or NSI students (*M* = 3.22, *SD* = 1.21). Less strong beliefs were identified also for AH students (*M* = 2.91, *SD* = 1.24) as compared to SSBAL students (*M* = 3.17, *SD* = 1.01) and NSI students (*M* = 3.22, *SD* = 1.21).

Kruskal-Wallis testing indicated significant differences for the item "When I use ICTs, I am more curious during learning," $\chi^2(5) = 15.505$, $p = 0.008$. Post hoc testing showed TEES students (*M* = 3.04, *SD* = 1.27) believed this less strongly than did NSMI students (*M* = 3.29, *SD* = 1.07), SSBAL students (*M* = 3.39, *SD* = 1.05), and HW students (*M* = 3.44, *SD* = 1.12). And AH students (*M* = 3.20, *SD* = 1.33) believed this less strongly than did HW students (*M* = 3.44, *SD* = 1.12).

Table 9. ANOVA Results for Student's Beliefs About ICT Use.

Items	**Study field - KLASIUS-P**	***M***	***SD***	**Between-group difference (Post hoc test /pairwise comparison)**
BEL1. Using ICTs for learning allows me to customize the learning process to my needs.	TEES	3.49	0.96	n.s
	AH	3.49	1.24	
	SSBAL	3.70	1.00	
	NSMI	3.64	1.01	
	EMC	3.50	0.97	
$\chi^2 = 11.008$, $p = 0.051$	HW	3.68	0.93	
	Total	3.60	1.01	
BEL2. Learning with ICTs is more fun than traditional learning.	TEES	3.10	1.10	TEES > SSBAL ($\boldsymbol{p = 0.013}$, $d = 0.66$)
	AH	3.03	1.30	TEES < HW ($\boldsymbol{p = 0.004}$, $d = 0.25$)
	SSBAL	2.36	1.13	AH > SSBAL ($\boldsymbol{p = 0.001}$, $d = 0.55$)
	NSMI	3.22	1.21	AH < HW ($\boldsymbol{p = 0.001}$, $d = 0.29$)
$\chi^2 = 20.880$, $\boldsymbol{p = 0.001}$	EMC	3.17	0.96	EMC > SSBAL ($\boldsymbol{p = 0.037}$, $d = 0.77$)
	HW	3.41	1.29	EMC < HW ($\boldsymbol{p = 0.010}$, $d = 0.21$)
	Total	3.22	1.08	NSMI < HW ($\boldsymbol{p = 0.027}$, $d = 0.15$)
BEL3. I have better grades because of use of ICTs for learning.	TEES	2.84	1.12	TEES < HW ($\boldsymbol{p = 0.040}$, $d = 0.23$)
	AH	2.91	1.24	TEES < EMC ($\boldsymbol{p = 0.020}$, $d = 0.25$)
	SSBAL	3.17	1.01	TEES < SSBAL ($\boldsymbol{p = 0.002}$, $d = 0.30$)
	NSMI	3.22	1.21	TEES < NSMI ($\boldsymbol{p = 0.001}$, $d = 0.32$)
$F(5) = 21.137$, $\boldsymbol{p = 0.001}$	EMC	3.12	1.13	AH < SSBAL ($\boldsymbol{p = 0.006}$, $d = 0.22$)
	HW	3.10	1.07	AH < NSMI ($\boldsymbol{p = 0.001}$, $d = 0.25$)
	Total	3.09	1.07	
BEL4. ICT use allows me to be more creative in learning.	TEES	3.11	1.08	n.s
	AH	3.17	1.12	
	SSBAL	3.27	0.99	
	NSMI	3.12	1.09	
$F(5) = 5.558$, $p = 0.352$	EMC	3.15	0.99	
	HW	3.28	1.01	
	Total	3.16	1.05	
BEL5. When I use ICTs, I am more curious during learning.	TTES	3.04	1.27	TEES < NSMI ($\boldsymbol{p = 0.003}$, $d = 0.21$)
	AH	3.20	1.33	TEES < SSBAL ($\boldsymbol{p = 0.005}$, $d = 0.30$)
	SSBAL	3.39	1.05	TEES < HW ($\boldsymbol{p = 0.001}$, $d = 0.32$)
	NSMI	3.29	1.07	AH < HW ($\boldsymbol{p = 0.035}$, $d = 0.18$)
$\chi^2 = 15.505$, $\boldsymbol{p = 0.008}$	EMC	3.23	1.10	
	HW	3.44	1.12	
	Total	3.49	1.36	
BEL 6. ICT use supports me in better collaboration with others.	TEES	3.47	1.04	n.s
	AH	3.43	1.14	
	SSBAL	3.70	0.93	
	NSMI	3.55	0.99	
$F(5) = 2.146$, $p = 0.056$	EMC	3.56	0.97	
	HW	3.59	0.92	
	Total	3.55	1.00	

Table 9. ANOVA Results for Student's Beliefs About ICT Use. (continued)

BEL7. ICTs allow me to learn anywhere.	TEES	3.64	1.29	n.s
	AH	3.50	1.42	
	SSBAL	3.77	1.20	
χ^2 = 8.086, p = 0.152	NSMI	3.61	1.31	
	EMC	3.57	1.28	
	HW	3.68	1.21	
	Total	3.63	1.13	
BEL8. Others (e.g., professors, colleagues) can see positive results, when I can use ICTs for learning.	TEES	2.61	0.89	n.s
	AH	2.69	1.02	
	SSBAL	2.81	1.02	
	NSMI	2.77	1.00	
	EMC	2.72	1.04	
	HW	2.57	1.08	
χ^2 = 10.628, p = 0.059	**Total**	2.71	1.00	
BEL9. Information gathered online is better than information from other sources.	TEES	2.50	0.75	AH < EMC (***p* = 0.019**, d = 0.34)
	AH	2.23	0.96	AH < NSMI (***p* = 0.001**, d = 0.46)
	SSBAL	2.75	0.91	AH < HW (***p* = 0.001**, d = 0.67)
	NSMI	2.59	0.91	AH < SSBAL (***p* = 0.001**, d = 0.55)
	EMC	2.53	0.76	TEES < SSBAL (***p* = 0.003**, d = 0.29)
χ^2 = 29.704, ***p* = 0.000**	HW	2.86	0.92	ECM < SSBAL (***p* = 0.008**, d = 0.26)
	Total	2.57	0.94	NSMI > SSBAL (***p* = 0.024**, d = 0.21)
BEL10. On the Web, I have access to learning information I could not get anywhere else.	TEES	3.59	1.11	n.s
	AH	3.72	1.07	
	SSBAL	3.85	0.96	
	NSMI	3.80	1.03	
	EMC	3.66	0.98	
F(5) = 10.724, p = 0.057	HW	3.78	1.08	
	Total	3.75	1.01	
BEL11. ICT use offers me a feeling of belonging to a group.	TEES	2.56	1.01	n.s
	AH	2.46	1.11	
	SSBAL	2.67	1.09	
	NSMI	2.52	1.11	
F(5) = 8.027, p = 0.155	EMC	2.47	1.08	
	HW	2.63	1.15	
	Total	2.55	1.09	
BEL12. Using the Web for learning, I can get access to more information than with any other source (e.g., books, professors).	TEES	2.95	1.29	AH < EMC (***p* = 0.004**, d = 0.28)
	AH	2.89	1.29	AH < SSBAL (***p* = 0.001**, d = 0.38)
	SSBAL	3.35	1.12	AH < NSMI (***p* = 0.001**, d = 0.28)
	NSMI	3.24	1.18	AH < HW (***p* = 0.001**, d = 0.38)
	EMC	3.22	1.05	TEES < EMC (***p* = 0.031**, d = 0.29)
	HW	3.36	1.15	TEES < SSBAL (***p* = 0.001**, d = 0.33)
χ^2 = 38.359, ***p* = 0.000**	**Total**	3.22	1.09	TEES < NSMI (***p* = 0.001**, d = 0.23)
				TEES < HW (***p* = 0.001**, d = 0.33)

Table 9. ANOVA Results for Student's Beliefs About ICT Use. (continued)

BEL13. Using ICTs for learning allow me to get to know other people better.	TEES	3.28	1.28	TEES < SSBAL (***p* = 0.007**, *d* = 0.23)
	AH	3.42	1.41	NSMI < SSBAL (***p* = 0.006**, *d* = 0.17)
	SSBAL	3.59	1.41	
	NSMI	3.35	1.28	
	EMC	3.37	1.24	
χ^2 = 11.522, ***p* = 0.042**	HW	3.38	0,79	
	Total	3.41	1.11	
BEL14. Using ICTs allow me better personal interaction with academic staff.	TEES	2.42	1.03	HW < NSMI (***p* = .021**, *d* = 0.22)
	AH	2.51	1.11	HW < EMC (***p* = .014**, *d* = 0.25)
	SSBAL	2.55	1.09	HW < AH (***p* = .007**, *d* = 0.27)
	NSMI	2.47	1.20	HW < SSBAL (***p* = 0.001**, *d* = 0.31)
	EMC	2.48	1.07	
χ^2 = 11.690, ***p* = 0.039**	HW	2.23	0.92	
	Total	2.46	1.04	
BEL15. On the Web, I can follow better trends in my study field.	TEES	3.76	1.00	TEES < EMC (***p* = 0.015**, *d* = 0.25)
	AH	4.00	1.05	TEES < SSBAL (***p* = 0.007**, *d* = 0.30)
	SSBAL	4.03	0.77	TEES < AH (***p* = 0.005**, *d* = 0.23)
	NSMI	4.08	0.86	TEES < HW (***p* = 0.003**, *d* = 0.31)
χ^2 = 14.130, ***p* = 0.015**	EMC	4.00	0.87	TEES < NSMI (***p* = 0.001**, *d* = 0.34)
	HW	4.07	0.85	
	Total	4.01	0.94	

Note. BEL–beliefs; TEES–Teacher Education and Education Studies; AH–Arts and Humanities; SSBAL–Social sciences, Business, administration and law; NSMI–Natural sciences, mathematics, and ICTs; EMC–Engineering, manufacturing and construction; HW–Health and welfare; $p < .05$ is in bold; n.s.–nonsignificant;

Significant differences in agreement with "Information gathered online is better than information from other sources," $\chi^2(5) = 29.704$, $p = 0.000$, was revealed by the Kruskal-Wallis testing. Post hoc testing indicated AH students (*M* = 2.23, *SD* = 0.96) agreed less strongly with this statement than did EMC (*M* = 2.53, *SD* = 0.76), NSMI (*M* = 2.59, *SD* = 0.91), HW (*M* = 2.86, *SD* = 0.92), and SSBAL (*M* = 2.75, *SD* = 0. 91) students. TEES students (*M* = 2.50, *SD* = 0.75) and EMC students (*M* = 2.53, *SD* = 0.76) also agreed less strongly than did SSBAL students (*M* = 2.75, *SD* = 0. 91). NSMI students agreed more strongly than did SSBAL students.

Kruskal-Wallis testing also indicated significant differences for agreement with "When using the Web for learning, I can get access to more information than with any other source (e.g., books, professors)," $\chi^2(5) = 38.359$, $p = 0.000$. Post hoc testing showed that AH students (*M* = 2.89, *SD* = 1.29) and TEES students (*M* = 2.95, *SD* = 1.29) agreed less strongly to this statement than did students of EMC (*M* = 3.22, *SD* = 1.05), SSBAL (*M* = 3.35, *SD* = 1.12), NSMI (*M* = 3.24, *SD* = 1.18), and HW (*M* = 3.86, *SD* = 1.15).

Significant differences in agreement with the statement, "Using ICTs for learning allows me to get to know other people better," $\chi^2(5) = 11.522$, $p = 0.042$, were revealed through the Kruskal-Wallis testing. Post hoc testing indicating TEES students (*M* = 2.42, *SD* = 1.03) and NSMI students (*M* = 3.35, *SD* = 1.28) agreed less strongly than did SSBAL students (*M* = 3.59, *SD* = 1.41).

Kruskal-Wallis testing indicated significant differences in agreement with "Using ICT allows me better personal interaction with academic staff," $\chi^2(5) = 11.690$, $p = 0.039$. Post hoc testing showed that HW students (*M* = 2.23, *SD* = 0.092) agreed less strongly to this belief than did NSMI students (*M* = 2.47, *SD* = 1.20).

Furthermore, Kruskal-Wallis testing revealed significant differences for the belief, "On the Web, I can better follow trends in my study field," $\chi^2(5) = 14.130$, $p = 0.015$. Post hoc testing indicating TEES students (*M* = 3.76, *SD* = 1.00) agreed less strongly with this than did students in all other disciplines.

No significant difference was found for the items: "Using ICTs for learning allows me to customize the learning process to my needs;" "I am more creative in learning, because of ICT use;" "Using ICTs for learning allows me better collaboration with others;" "ICTs allows me to learn anywhere;" "Others (e.g., professors, colleagues) can see positive results when I can use ICTs for learning;" "On the Web I have access to learning information I could not get anywhere else;" and "Using ICTs for learning gives me feelings of belonging to the group."

DISCUSSION

Higher education prepares graduates for the requirements of dynamic work contexts with rapid technological innovation by providing opportunities to develop professional competences as a component of the study-field curriculum. An essential characteristic of a future professional is the readiness for lifelong learning and competent work with technologies. Subject-specific competences in higher education curricula need to be delivered through the integration of 4C processes and skills for working with technology; it already has been established that technology integration into teaching and learning in university learning environments makes an important contribution to students' development of various competences and skills (Adams Becker et al., 2017; Jääskelä et al., 2017). Additionally, prior research has established that technology integration in higher education teaching currently is insufficient (Instefjord & Munthe, 2017) and that teaching with ICT integration provides students with authentic learning experiences (Istenič Starčič et al., 2018). Authenticity in teaching is achieved by integrating students' existent ICT practices with anticipated professional ICT practices. It supports enactive learning in terms of learning by doing and vicarious learning by observing the performance of someone modeling the skills (Bandura, 1971, 1986).

Previous research suggests disciplinary differences in digital competence (Owens & Lilly, 2017) and ICT integration in higher education (Croteau et al., 2015). Our research was motivated by interest in the differences in ICT integration within university learning environments. Our findings demonstrate several differences among students in various disciplines within a single university.

In the Results section, we identified that, overall, the frequency of technology use is not very high and that students of different disciplines varied significantly regarding their use of ICTs in an academic environment, how ICTs are integrated within their learning environments, and how they viewed their teachers as good models for employing ICTs for learning and collaboration. In this section, we discuss how TEES students are different from other disciplines. TEES students will, in their professional practice, prepare future young generations of students for life and work in digitalized society.

The Difference Among Disciplines in Students' Perceptions of Teacher's ICT Integration in Teaching Corresponding to the Frequency of ICT Use by Teachers

Concerning technology integration in higher education in terms of their teachers' frequency of technology use in teaching, we identified differences in three scale items of five. Specifically, the data revealed differences in "ICT use during classroom lectures and tutorials for students' activities," "ICT use outside classroom lectures for learning content prior to organized class lectures," and "ICT use for feedback and assessment." TEES students perceived that teacher-educators organize ICT-supported collaboration activities during classroom lectures more than was perceived for teachers in other disciplines. However, TEES students perceive that their educators rarely conducted a flipped classroom or facilitated BYOD. Based on these findings, we could conclude that ICT utilization for TEES in providing feedback and assessment is insufficient. Computer-assisted feedback and assessment to support students' informed learning decisions is important for current and future trends and should be introduced to student teachers. Second, an important conclusion regarding TEES students is the need for populating flipped classroom activities utilizing online learning resources. Offering a variety of resources for enhancing students' self-directed learning and for merging imposed and selected learning environments.

The Difference Among Disciplines in Students' Perceptions of University's Requirements for ICT Use

Regarding technology integration requirements in the university learning environment, interdisciplinary differences were apparent in all scale items. TEES students had relatively higher means than other groups for "I am required to use ICTs for which I do not get adequate training" and "I am required to use ICTs for computer-supported collaborative learning." Their mean scores were the second highest in both areas. For the statement, "I am required to use ICTs for independent study," the TEES students' mean was the highest.

Our findings about TEES students show they perceive the requirements of their university learning environments in favor of computer-supported collaborative learning and for independent study. Based on these results, we could conclude that university requirements generally support students in developing self-regulation skills for learning from online learning resources. Computer-supported collaborative learning offers significant potential for learning about new technologies and technology integration in teaching. Referring to TEES students specifically, the indication of their lack of ICT training should be examined in the future. To benefit these students, it would be important to identify which tools and technologies they are skilled in currently and what is expected from them to develop on their own.

The Difference Among Disciplines in Students' Perceptions of the Teacher as a Role Model in Technology Integration

Differences exist in all items of the scale for this focus area. Related research highlighted that initial teachers' education has a high potential for developing student teachers' competences for technology integration (Drent & Meelissan, 2008; Paratore et al., 2016), which will in turn influence future generations of students when the student teachers start their professional pedagogical practice. Related research identified great potential for the teacher-educator as a role model and designer of the digitalized curriculum (Katyal & Evers, 2004; Lai, 2015; Tondeur et al., 2016). Our findings show that, compared with other disciplines and as perceived by their students, teacher-educators are effective, from a professional competence standpoint, in designing and role modeling the integration of ICTs into the curriculum. TEES students’ perceptions of their teacher-educators as successful in using ICTs are second only to students in NSMI, a field that includes the study of ICTs. TEES students also felt that teacher-educators are at least as competent in ICT use, which is in line with the perceptions of students in NSMI and EMC.

We found, however, that students wanted teachers to play a more active role in leading technology innovation in educational environments. Students from ICT-specific disciplines perceived programs and professionals as equally good in achieving this due to highly specific and up-to-date technological and content knowledge. These NSMI students’ perspectives were revealed as significantly different from other disciplines, both in using innovative solutions and being enthusiastic about ICT use. TEES students, however, did not perceive their teachers to be very advanced in using innovative technological solutions; the same applies to enthusiasm about ICT use. Pintrich and Schunk (1996) defined enthusiasm and credibility as characteristics of a good role model. TEES, AH, and HW students differed significantly from students in NSMI in their perceptions about teachers’ use of innovative technological solutions. With regard to enthusiasm for ICT use, TEES, AH, and SSBAL students’ perceptions varied significantly from NSMI students. TEES students also significantly varied from ECM students.

We could conclude that, as perceived by their students, teacher-educators are effective in designing and role-modeling the integration of ICTs when compared to other disciplines. They are not perceived, however, as leaders in new technology use. In their research in Flanders, Belgium, Tondeur et al. (2016) concluded that teacher-educators do not provide sufficient modeling regarding using ICTs as components of their pedagogical practices. In Norway, Instefjord and Munthe (2017) found that preservice teachers have very diverse perceptions of their teacher-educators as role models generally and, on average, a neutral perception of teacher-educators as role models in ICT integration in teaching.

Researchers in one study from Canada identified a negative correlation between perceived teachers’ ICT integration and perceived learning gain among students of different disciplines (Venkatesh et al., 2014). Another study of Canadian teachers established that teacher-educators perceive a limited potential for ICT use in higher-education teaching in contributing to students’ learning (Croteau et al., 2015). Therefore, both sides of this issue (i.e., the students’ and the teachers’ views of contributions of ICTs to students’ learning) need to be examined further. The ICT integration in the education process is a complex issue, context dependent, and related to a set of factors and its interplay. On the other hand, technology development is rapid, which requires teachers take into consideration a critical evaluation of diverse issues and factors.

The Difference Among Disciplines in Students’ Perceptions of ICT Use for Collaboration

We identified a statistically significant difference between disciplines in 4 scale items of 10 regarding ICT use for collaboration. Of all disciplines, TEES students used ICTs most frequently for participating in online communities where they knew the majority of students. In this, they differed significantly from AH, SSBAL, and NSMI students. TEES students also engaged in computer-supported collaborative learning and shared their own files for learning with fellow students more frequently than did students from most of the other disciplines. They did not lead, however, in activities in social networks, such as engaging in discussions, following educational content suggested by computer-recommendation systems, or posting blogs with content from their study field. TEES students also sought help online least frequently and were less likely to utilize social networking frequently for co-creating documents; however, they quite frequently share resources and information. Related research among university students in USA identified student participation in Internet-facilitated collaboration, project work, exchanging notes, sharing, and ICT use for studying for exams (Jones, Johnson-Yale, Millermaier, & Perez, 2008). TEES students seem to build social groups to support their learning process in collaboration with classmates and people they know and tend to exploit social networking more for interacting in a familiar environment. In their professional role, however, they will be expected to build relationships in new groups and interact with people they do not know. Therefore, these key expectations of a teacher-educators need to be clarified and examined further.

The Difference Among Disciplines in Students' Beliefs About ICT Use

Statistically significant differences were evident in 8 of 15 scale items in this area. Beliefs about ICT use are predictors of its use (Sang et al., 2010), and such beliefs need to be examined in the higher education environment for two main and interconnected reasons. First, the educational sector has a low ranking on the Sector Digitalisation Index (Manyika, 2015), despite the important role that classroom teachers play in developing the digital competences of the upcoming generations of students. Second, initial education is regarded as having the potential for transforming beliefs (Paratore et al., 2016) that could reduce the attitude–behavior gap (Istenič Starčič et al., 2018).

In related studies, beliefs about ICTs in learning refer to improving learning performance, efficiency, individualization and differentiation in learning, and the level of creativity of students (Sang et al., 2010). ICTs also are essential components of the observability of results and for facilitating flexibility in learning (van Braak & Tearle, 2007).

We examined beliefs about ICT use in learning by referring to collaboration as the main affordance of ICTs (Conole & Dyke, 2004), their potential for student-centered teaching (Means & Olson, 1997), and as a result of ICT integration (Hao & Lee, 2017; Hattie, 2009; Tondeur et al. 2016). Our findings indicate that no significant difference exists between disciplines regarding beliefs about ICT use for collaboration or whether it enhances feelings of belonging. TEES students have less strong beliefs regarding ICTs providing better personal interaction with academic staff or allowing them to know other people better. A study by Jones et al. (2008) found that Internet use had a positive impact on relationships among classmates and that online communication is used extensively for communicating with professors.

Referring to creativity, we examined beliefs about a student feeling more creative when using ICTs as well as technologies' ability to further curiosity, fun, and flexibility in learning. In the present study, we identified no significant difference among the disciplines in their perceptions or their practices of being more creative in learning because of ICT use. We found, however, in comparison to SSBAL students, that TEES students have stronger beliefs about ICTs providing fun environments. They have less strong beliefs about items referring to ICT use in learning for curiosity. And there was no difference among their peers from other academic fields regarding the observability of learning outcomes.

Regarding flexibility in learning, we found no significant difference among the student groups in terms of customizing the learning process to student needs, the opportunity for learning anywhere, or access to information that could not be accessed elsewhere. TEES students had less strong beliefs about customizing the learning process to their personal needs, the availability of information online (i.e., better information than elsewhere or more information than elsewhere), or that professors can see results, when using ICT for learning.

CONCLUSIONS

Our study compared the effectiveness of ICT integration across disciplines and revealed several differences that rarely have been explored in prior research. The study was an exploratory one, conducted in a single institution, with the goal of identifying issues for future study. The sample size was small, considering the large number of students invited to participate. The most likely reason for this is that authors conducted the study during the examination period, which not the best time to ask students to participate in a survey. Despite the low participation rate, the data collected did contribute to our goals of identifying and understanding better the issues and surfacing questions for further research.

The self-reported perceptions provide only a partial insight into the myriad issues of technology-enhanced learning environments. An in-depth analysis of the topic generally, and of any research finding specifically, would require a mixed-method study of a larger sample of students and teachers, following, perhaps, the methods applied in a Canadian study (Croteau et al., 2015), in which large differences were established between teachers' and students' views.

Technology integration refers to a wide spectrum of tools and online learning resources. Effective implementation of any such practices requires the analysis of diversified educational technologies in various contexts, disciplines, and learning methods. Moreover, the increasing requirements for digitalization of higher education requires a comparative analysis of students' and teachers' experiences to inform technology integration. In the future, various factors that are context dependent and related to students and teachers should be examined with explanations provided for their predictive power to development of students' 21st-century skills.

Among reasons reported for insufficient ICT integration in teaching are the lack of research and training at the tertiary level (Instefjord & Munthe, 2017) and lack of understanding of higher education teachers' beliefs about technology-integrated teaching and learning (Jääskelä et al., 2017). Our research addressed part of this gap, providing some insight into students' perceptions that should help guide teachers' pedagogical decisions and institutional and system interventions for enhancing teachers' pedagogical competences towards increased impacts on graduates professional competency.

The education sector, being very low on the Sector Digitalisation Index (Manyika, 2015), is facing the requirement to educate the university-aged population for lives and professions in a digitalized society. The P21 project established that students develop professional competences when learning skills and skills for work with technology are integrated (P21, 2012; P21 & AACTE, 2010). The findings of the present study indicate differences among academic disciplines that suggest such differences need to be explored from a variety of teaching and learning perspectives. Future research must consider students' life experiences and the expectations of the university learning environment in relation to real-life professional contexts (Istenič Starčič et al., 2018).

The present study identifies teachers as role models, highlighting their leading role in ICT use and advancing the professional use of ICTs. TEES students identified teacher-educators as currently not playing the role of leaders in bringing technological innovation into the classroom or curriculum. Students' beliefs about ICT use show that TEES students have less strong beliefs about ICTs supporting interaction and devising online information. This is in line with the deficiency identified in social network practices, discussing in social networks in the study field, posting blogs, deploying recommendation systems, and co-creating documents, when compared to students in other disciplines.

Based on findings, we identified a need for teacher-educators addressing rapidly developing technological innovation and its efficiency for interaction in learning process and learning environment design. In the future, these needs, among many, require broader examination as a foundation for preparing future educational professionals for ongoing work with technology and for technology use in lifelong learning. In a technologically rapidly developing society, teacher-educators must design their teaching practices in the present for their students' benefit in the future, and thus must critically address the constantly evolving technology.

In line with related studies, the findings of the present study establish the difference in ICT implementation in teaching and learning among higher education professional disciplines (Croteau et al., 2015). So although this paper has focused on the implications of our findings for students in the education discipline, broader and deeper exploration other disciplines regarding these issues are needed in the future.

IMPLICATIONS FOR RESEARCH AND APPLICATION

The findings of this exploratory study raise questions about instructional design in all disciplines when integrating a guided learning environment, which is imposed by a university, with the unstructured learning environment driven by student planning. From a research perspective, this study contributes to the limited current findings regarding students' perceptions of technology integration as useful for their current learning and future professional applications. Thus, it provides a basis for larger studies of this nature and for deeper investigation into the myriad issues related to the triad of technology-enhanced learning—from the universities' directives, to the teachers' implementations of new ICT-based pedagogical practices, to the students' embracing and encouraging effective and integrated use of technologies that will prepare them better for their transitions to ICT-infused professional environments. It is especially important to look at authentic ICT use, which enhances teaching and learning in and of itself as well as develops students' subject-specific professional competences.

With students and teacher-educators in the education field as a focus in this study, our research provides evidence that more study of the specific formation of future teachers is essential for creating environments and academic structures aimed at the influences on future learning. Even now, however, instructional design must provide student teachers with opportunities for selecting and making decisions in creating their personal digital learning environments and networks. This emphasis on studying and developing the ICT-based skills for tomorrow's teaching professionals rests particularly on social media, activities widely engaged by the current young generation of students. Teachers' social media use and competences should be examined more closely. Moreover, current and future teachers need support and data to address the challenges raised by the digitalization of childhood, in terms of both the learning potential of students' familiarity with specific ICTs and the consequent problems and educational impact caused by compulsive use of social media.

From the application perspective, the results of our study clearly indicate that some changes already can be implemented in ICT-based higher education. At the university level, planning for the digitalized curriculum requires sufficient time, training, and investment in a larger variety of learning methods, learning technologies, and collaborative activities for both teachers and students. For the teachers, tools and research already exist on ways they can design their current and future curricula and pedagogical decisions to address students' creativity and engagement in collaborative work with technology to raise their capabilities for being autonomous, self-directive, and self-efficient in their workplaces. Teachers also can immediately take on the clear understanding that they, as professionals, are role models for ICT use and for the ongoing process of lifelong learning of new processes and technologies. On the other hand, students need to develop not only an understanding of the various ways ICTs can enhance their current studies and future work-related activities, but also take an active role in underscoring the need for these with both university administrators and in-class educators. In that way, students serve as co-creators—or at least motivators—of flexible and responsive curricula for their fields of study.

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Abstract: *Recognition of the importance of evidence-based technological tools that provide personalized learning opportunities is growing. This paper reports on a pilot study evaluating GraphoLearn for Standard Indonesian, a digital game environment that trains basic reading skills by extensive-but-playful exposure to grapheme–phoneme correspondences. The results obtained from 33 Indonesian first graders show that game progress was found to be a significant predictor of reading and decoding abilities both at the posttest and the 5-month follow-up assessment. Our results additionally indicated a significant interaction effect of game progress and letter–sound knowledge at posttest: Progress in the game was strongly related to reading and decoding fluency, but only for students with average to above-average pretest letter knowledge. To enable students with low letter knowledge at the outset to benefit fully from the game as well, we suggest extending the playing period to approximately 6 months to establish firmly letter knowledge and phonological awareness skills.*

Keywords: *technology-enhanced reading support, reading acquisition, digital learning environment, GraphoLearn, GraphoGame, Standard Indonesian.*

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VERTAISARVIOITU KOLLEGIALT GRANSKAD PEER-REVIEWED www.tsv.fi/tunnus

INTRODUCTION

Dyslexia is the most prevalent learning disability in modern societies, where the ability to read is an essential skill to be able to fully participate (Cortiella & Horowitz, 2014). Prevalence rates depend on the exact definitions and diagnostic criteria used. However, following a common definition in which the cutoff for reading achievement is set at 1.5 standard deviations below the mean for age, 7% of the general population can be identified as being dyslexic (Peterson & Pennington, 2015). Children with dyslexia face not only persisting problems with reading and spelling (Lyon, Shaywitz, & Shaywitz, 2003) but also negative effects on cognitive development, school motivation, well-being, and self-esteem (Lovio, Halttunen, Lyytinen, Näätänen, & Kujala, 2012). Within the field of learning difficulties, evidence-based technological tools that provide personalized learning opportunities increasingly are recognized as important (Beddington et al., 2008; Kyle, Kujala, Richardson, Lyytinen, & Goswami, 2013). If these tools are designed in such a way that progress depends on learning, struggling learners can be given more practice opportunities; such tools also create the possibility for individualized instruction and support.

In this paper, we discuss the results of an extended pilot study using GraphoLearn for Standard Indonesian (GraphoLearn SI), a digital learning environment that trains basic reading skills by extensive-but-playful exposure to grapheme–phoneme coupling. The development of effective language-specific reading acquisition programs and interventions such as GraphoLearn, which is based on thorough knowledge of orthographic features, can be of great value to any struggling reader. Even more so, such programs can benefit those students learning to read orthographies that have not yet been extensively studied, where the development of such tools can play an important role in preventing illiteracy or alleviating difficulties resulting from dyslexia.

GraphoLearn SI

Since its creation through collaboration between the University of Jyväskylä and the Niilo Mäki Institute in Finland, multiple language versions of GraphoLearn[1] have been developed that follow the same key principles, although adjusted to the specific language characteristics. An important characteristic of the training is its focus on the most functional sublexical units of the particular orthography being learned (Richardson & Lyytinen, 2014). For readers developing skills in transparent alphabetic orthographies with consistent grapheme–phoneme correspondences, such as the Standard Indonesian language (see the Standard Indonesian Orthography section for more details), the simplest and quickest way of learning to decode is to focus on exactly these connections (Holopainen, Ahonen, & Lyytinen, 2002; Landerl, 2000). Effectiveness studies evaluating GraphoLearn methods have, so far, shown promising results (e.g., Brem et al., 2010; Kyle et al., 2013; Saine, Lerkkanen, Ahonen, Tolvanen, & Lyytinen, 2010, 2011).

We designed GraphoLearn SI to support primarily young students whose SI reading skills appear to lag behind those of their peers at the elementary stages of formal reading instruction. In the game, the player moves his/her game character around on a randomly generated map in an attempt to reach a door that leads to the next game level. Along the way, the player passes fields that may contain an item (e.g., a funny hat for the game character to wear) or an exercise. The game's key exercises consist of both paced and unpaced multiple-choice trials in which the player needs to match an acoustic stimulus (a phoneme, syllable, or word) to the corresponding written representation on the screen. These reactive types of trials alternate with more active tasks in which the student constructs written words from smaller components to match the spoken target words. For example, the student hears the word *kamu* /kamu/ [you] and needs to construct the written word using two syllable blocks *ka* (/kɑ/) and *mu* (/mu/). Based on the performance in each particular trial, the content of the subsequent trials is automatically adapted to the student's level with the aim to offer sufficient challenges as well as opportunities for success (Richardson & Lyytinen, 2014).

Our research group developed two versions of GraphoLearn SI: The main design comprises 21 streams subdivided into 333 levels, whereas a compressed version offers the same 21 streams but in 177 levels. In line with other GraphoLearn studies (e.g., Kyle et al., 2013; Saine et al., 2010), the main design was developed to be played during five 10- to 15-minute sessions per week (see also Richardson & Lyytinen, 2014). The compressed version was created to accommodate school settings in which this preferred playing frequency would not be possible due to practical restrictions and where the complexity of the game content still needed to coincide with the level of the students' regular classroom reading instruction (see also Borleffs, 2018;[2] Borleffs et al., 2018). Details of the theoretical background, development, and design of GraphoLearn SI are described extensively in Borleffs et al. (2018). The Borleffs et al. (2018) paper additionally discusses the results of a pilot study among 69 typical and struggling beginning readers recruited from first-grade classes of an elementary school in the city of Medan (Sumatra, Indonesia). Students participating in the study published in 2018 played the compressed version of the game at a relatively low frequency: Between October and March 2015, the students attended, on average, nine GraphoLearn sessions of 15–20 minutes. The results of this pilot study were promising and indicated that the more the students with low pretest phonological skills were exposed to the game, the better their posttest performance on reading and decoding fluency. We, of course, still need more large-scale randomized controlled studies to explore further the effectiveness of our game designs.

In the present study, we tested a more intensive approach than we did in our 2018 pilot study by having 33 first-graders from a more rural area, that is, the outskirts of Medan, play the main design more frequently during a shorter period of time (see Methods section for more details; also see Borleffs, 2018). The aims of this extended pilot study were to evaluate further GraphoLearn SI's usability, test the association of progress in GraphoLearn in promoting reading and reading-related skills in first-grade learners of Standard Indonesian, and use the data acquired during this study to improve the game design.

Standard Indonesian Orthography

Standard Indonesian (SI) is a standardized dialect of the Malay language (Sneddon, 2003). For approximately 23 million Indonesians, SI is their primary language, and another 140 million speak SI as a second language (Lewis, Simons, & Fennig, 2013). SI has a highly transparent alphabetic orthography with an almost one-to-one correspondence between phonemes and graphemes in both the reading and spelling direction (i.e., phoneme to grapheme and grapheme to phoneme), including a close correspondence between letter names and letter sounds (Winskel & Widjaja, 2007). The alphabet coincides with the 26 letters of the English alphabet, albeit the letter *x* is only used in loan words. SI has numerous transparent morphemes and affixations (Prentice, 1987). Colloquial SI, however, often features nonaffixed forms. The affixes have at least one semantic function and differ as a function of the word class of the stem. For example, the active verb and stem word *makan* [to eat] becomes the noun *makanan* [food] or the passive verb *termakan* [to be eaten] after adding the suffix *-an* and prefix *ter-*, respectively (Winskel & Widjaja, 2007). The majority of words are multisyllabic; monosyllabic words are rare. The syllable structures are simple and have clear boundaries (Prentice, 1987; Winskel & Lee, 2013). As many textbooks for first-graders already feature words with derivational affixes, Indonesian schoolchildren need to master long words early in their education (Winskel & Widjaja, 2007).

METHODS

Sample

In Indonesia, primary schooling begins at the age of six for most children and is compulsory for all. During reading instruction in the 2nd year of kindergarten (children aged 5 years), students generally start to acquire some letter knowledge. However, the enrollment of children in early childhood programs (e.g., playgroup, kindergarten) is limited in Indonesia, with families living above the poverty line being more likely to enroll their children in such programs than are families living in poverty (World Bank, 2006). Moreover, educational services in Indonesia are biased toward urban areas, where the percentage of children attending preschool programs in 2003 was twice as high as in rural areas (Sardjunani & Suryadi, cited by Sardjunani, Suryadi, & Dunkelberg, 2007).

We recruited 37 first graders from a small private Christian school in one of the suburbs of Medan (Sumatra), where education is provided in SI. The teacher taught all participants using the same teaching method. Reading instruction started with the introduction of the alphabet. Once the students had memorized the letter names, they were taught to combine consonants (C) and vowels (V) to form syllables with a simple CV structure (e.g., *b+u* to produce the syllable *bu*). Subsequently, the students were instructed to combine V and CV syllables patterns to form words (e.g., *i+bu* to create the word *ibu*, meaning mother) before learning syllables with a CVC pattern and more complex CV combinations. All students had a low- to middle-socioeconomic background and were fluent in SI, including one bilingual student who also spoke a regional language (Batak) at home.

Of these 37 candidates, 33 were eligible to participate in the study. Three students were excluded from the data analyses, as their cognitive abilities to play the game were insufficient, whereas the fourth student rarely attended school, missing both pre- and posttest sessions and most of the GraphoLearn sessions.

Table 1 describes the demographics of the 33 participants at the administration of the pretest. Thirty-one students had attended only 1 year of the 2-year kindergarten program, and two students had not attended kindergarten at all.

Measures and Procedure

All students played GraphoLearn SI during various prescheduled supervised group sessions at school in the period between August and November 2015, with the player data recorded onto a server for offline analysis. The students' reading and reading-related skills were assessed during

Table 1. Demographics of the Study Sample at Pretest.

	Grade 1
N	33
Boys; girls	20; 13
Mean age in years for all students [range]	6.5 [5.3–7.3]
SD age	0.65
Kindergarten attendance [boys; girls]	19; 12

three individual test sessions using paper-and-pencil tests completed prior to the start of the GraphoLearn SI training in August (pretest, second or third week of school; $N = 30$), at the end of the training in November (posttest; $N = 33$), and at a follow-up in April 2016 (follow-up; $N = 31$). Moreover, the students participated in a computerized in-game assessment at both pretest and posttest. Two of the 33 students had started school a few weeks late and therefore missed the pretest and, after two attempts, another student proved too shy to take the pretest. In Week 4 of the school year, all students started playing GraphoLearn SI following 3 weeks of formal reading instruction.

The descriptive statistics of the GraphoLearn SI player data are presented in Table 2. Our aim was to have the students play the game five times a week for 13 weeks between August and November, excluding the midterm exam week. We also tracked any lack of play due to school absence or technical issues, which was typical for all children and negatively impacted the goal of five sessions a week. We recorded an average of 2.9 sessions per week with an average playing time of 11.3 minutes per session. These statistics reflect the time during which students were actually exposed to the educational content and had spent completing game levels, excluding the time during which they explored the map between levels. The overall average time spent using the game was 10–15 minutes per session.

The majority of the behavioral measures used were taken from a recently developed assessment battery for beginner readers of SI (Jap, Borleffs, & Maassen, 2017). Additionally, we created and presented an auditory synthesis task (modeled after a Dutch version developed by Verhoeven, 1993, drawing its content from commonly used Indonesian first-grade textbooks), as well as two subtasks from the Snijders-Oomen nonverbal intelligence test (SON-R 6-40; Tellegen & Laros, 2011). When necessary, the instructions were translated into Standard Indonesian, but the original task content was maintained (also see Borleffs et al., 2018).

Table 2. Descriptive Statistics of GraphoLearn Player Data after 13 Weeks ($N = 33$).

	Minimum	Maximum	Mean	Median	*SD*
Total playing time (h)	3.73	9.69	7.13	7.28	1.62
Number of playing sessions	18	50	37.8	39	7.9
Total number of levels played	198	682	457	477	124
Levels played per minute	0.78	1.50	1.07	1.03	0.19
Highest level reached	7	333	193	175	122
Total number of items seen	10,413	35,744	23,930	24,486	7,206
Total number of responses given	2,621	8,813	6,004	6,151	1,658

The following tasks were completed at pretest: SON-R categories and analogies (nonverbal intelligence test), digit span forward and backward, phoneme deletion, auditory synthesis, Rapid Automatized Naming (RAN) objects, colors, and if possible, based on students' sufficient knowledge, digits and letters. The pretest sessions took approximately 35 minutes, on average.

At posttest and follow-up measurements, word reading and pseudoword reading were assessed, in addition to all tests from the pretest, except for the SON-R subtasks. Posttest and follow-up sessions each took approximately 20 minutes, on average. The tests comprised

- WORD READING. We presented the student with a list of 100 lowercase multisyllabic (2–4 syllable) words printed on an A4-size laminated sheet of paper. Reading fluency was defined as the number of words correctly read aloud within 1 minute.
- PSEUDOWORD READING. We presented the student with a list of 100 lowercase multisyllabic pseudowords (2–4 syllable) printed on an A4-size laminated sheet of paper. Decoding fluency was defined as the number of pseudowords correctly read aloud within 2 minutes.
- PHONEME DELETION. The researcher instructed the student to verbally repeat a pseudoword articulated, after which (s)he was asked to leave out a particular phoneme from the presented pseudoword. The phoneme-deletion score was calculated as the number of correct answers.
- AUDITORY SYNTHESIS. The researcher presented 20 words (2–5 phonemes per word) by articulating the individual phonemes one by one, after which the student was asked to blend these sounds into a spoken word. The auditory-synthesis score was calculated as the number of correct answers.
- RAPID AUTOMATIZED NAMING (RAN). We showed the student five columns of 10 objects, colors, digits, or letters printed on A4-size laminated sheets of paper and asked him/her to name these from top to bottom as fast and as accurately as possible. Each RAN subtest score was calculated as the number of items per second correctly named by the student.
- DIGIT SPAN FORWARD AND BACKWARD. The researcher asked the student to repeat spans of digits of increasing lengths, in forward fashion during the first task and in backward fashion during the second. Both digit-span scores were based on the number of correctly reproduced trials.
- CATEGORIES AND ANALOGIES (SON-R 6-40; Tellegen & Laros, 2011). Both SON-R subtasks measured abstract reasoning and consisted of three groups of 12 test items. In the categories task, the student had to find the common characteristic in three pictures and subsequently point at two other pictures (of five new pictures) that also possessed this feature. In the analogies task, the student had to discover the principle of change of an example analogy where one geometrical figure changed into another geometrical figure and apply this principle to another comparable figure. Both SON-R scores were based on the total number of correct answers.

The in-game assessments completed during the pre- and posttest sessions were part of a larger test battery. Below, we describe the assessments analyzed in our present trial:

- LETTER–SOUND KNOWLEDGE-PART I. The researcher asked the student to match a target speech sound to the corresponding grapheme presented on the screen together with seven or eight distractors (e.g., target /d/ with distractors ⟨d | e r i n k a ai⟩).

The score for this test was calculated as the number of correct answers in the 25 presented phonemes.

- LETTER–SOUND KNOWLEDGE-PART II. We asked the student to match a target speech sound to the corresponding grapheme. Each target grapheme was presented on the screen together with five more confusable distractors than in Part I (e.g., target /ŋ/ with distractors ⟨ng | n m g ny y⟩). This second letter–sound knowledge score was calculated as the number of correct answers for the 10 presented phonemes.
- NUMBER KNOWLEDGE. We asked the student to match a spoken digit, ranging from 0 to 20, with the corresponding written representation. Each target was presented on the screen together with 9 or 10 distractors (e.g., target digit 19 with distractors ⟨19 | 1 2 9 17 11 4 15 14 5⟩). The number-knowledge score was calculated as the number of correct answers in the 21 presented digits.
- LEXICAL DECISION (only at posttest). The researcher showed the student 16 words (e.g., *kue, sampai, di*) and 16 pseudowords (*tue, simpau, ki*), one at a time, and asked to decide whether or not the presented word was a real word by selecting a button with a red cross (is not) or a green check mark (is real). The score was calculated as the number of correct answers.

RESULTS

Students' Performance Across Three Test Points

Table 3 lists the performance scores for the pre-, post-, and follow-up tests (16 in total) in mean values and standard deviations and the results from the paired samples *t* test or Wilcoxon signed-rank test. Several variables were not normally distributed, in which case we used the nonparametric alternative for the paired samples *t* test.

As a result of insufficient letter and/or number knowledge, respectively eight and six students were not able to take the RAN letters and/or RAN digits subtest at pretest. If, prior to the RAN subtest (i.e., during the practice activity), a student was not able to correctly name any of the digits or letters in the last column of the pretest (while the rest of the columns were covered), we excused the student from taking the specific subtest. Following the same protocol, missing posttest data were reported for three students on the RAN letters task and for two students on RAN digits. With regard to the SON-R scores, we unfortunately were able to collect scores for only two thirds of the students (22 of 33). We therefore decided to exclude the SON-R scores from further analyses for this paper. Moreover, correlations between SON-R scores and reading fluency were close to zero, showing that the SON-R scores did not relate to reading levels in our sample.

As shown in Table 3, the paired pre–post differences were significant for auditory synthesis, all four RAN tasks, the in-game number-knowledge assessment task, and both letter–sound knowledge tasks. The paired posttest–follow-up differences yielded significant results for reading and decoding fluency, phoneme deletion, and RAN colors, digits, and letters.

Table 3. Descriptive Statistics of the Pre-, Post-, and Follow-up Tests Results and the Paired Posttest–Pretest and Follow-up–Posttest Differences.

	Pretest			**Posttest**			**Follow-up Test**			**Paired Differences Posttest–Pretest**		**Paired Differences Follow-up–Posttest**	
	N	Mean	*SD*	*N*	Mean	*SD*	*N*	Mean	*SD*	*t* / *Z**	Sign.	*t* / *Z**	Sign.
Reading fluency	-	-	-	33	14.7*	16.0	31	28.2*	25.1	-	-	4.23*	<.001**
Decoding fluency	-	-	-	33	17.6*	19.0	31	27.3*	24.8	-	-	3.95*	<.001**
Auditory synthesis	30	1.90*	2.14	33	4.85*	4.24	31	6.77*	5.37	2.99*	.003**	1.76*	.079
Phoneme deletion	30	0.47*	1.01	33	0.45*	1.30	31	2.26*	4.57	-0.30*	.764	2.70*	.007**
Digit span forward	28	4.29	1.80	33	4.76*	1.52	31	4.55*	1.73	1.39*	.164	0.20*	.839
Digit span backward	30	0.80*	1.03	33	1.33*	1.29	31	1.48*	1.15	1.91*	.057	1.19	.232
RAN colors	28	0.43	0.25	31	0.56	0.26	31	0.58	0.27	4.28	<.001**	2.10	.045**
RAN objects	30	0.56	0.18	33	0.68	0.14	31	0.71	0.21	4.55	<.001**	1.45	.159
RAN digits	27	0.61*	0.30	31	0.95*	0.34	31	1.00	0.41	4.54*	<.001**	3.58*	<.001**
RAN letters	25	0.56	0.29	30	0.97	0.42	31	1.10*	0.55	8.13	<.001**	3.44*	.001**
SON analogies	22	5.36*	3.58	-	-	-		-	-	-	-	-	-
SON categories	22	4.68*	4.09	-	-	-		-	-	-	-	-	-
Number knowledge	28	15.9*	6.43	29	18.2*	5.44		-	-	3.06	.002**	-	-
LS knowledge I	28	11.3	5.90	29	15.8	4.88		-	-	2.94	.007**	-	-
LS knowledge II	27	4.78	2.21	27	6.15	1.99		-	-	3.14	.005**	-	-
Lexical decision	-	-	-	29	15.9*	5.09		-	-	-	-	-	-

Note. LS knowledge = letter–sound knowledge. RAN = rapid automatized naming score in items correctly named per second. SON-R = Snijders-Oomen nonverbal intelligence test

* One or both variables are not normally distributed. Nonparametric Wilcoxon signed-rank test is used instead of paired samples *t* test.

** Mean difference is significant at the .05 level

Correlations

Interrelationships among 14 tests (excluding SON-R categories and analogies) and the GraphoLearn (GL) variables mentioned in Tables 2 and 3 were examined using a correlation matrix (Spearman's rho) and are listed in Table 4. Notable are the significant posttest correlations between the GL variables highest level achieved and levels completed per minute and the phonological awareness tasks (a) phoneme deletion and (b) auditory synthesis, both of which were lacking significance at the pretest. By contrast, looking at both the letter–sound knowledge and number knowledge tasks in relation to the GL variables, we generally found higher correlations for the pretest than for the posttest scores. As for the RAN tasks, we found significant correlations with several GL variables at all three test sessions, with the correlations generally being most apparent at posttest.

As shown, both posttest and follow-up reading and decoding fluency scores correlate significantly with the highest GL level reached and the number of levels played per minute. At follow-up, reading and decoding fluency additionally correlate significantly with the total number of levels played. The correlation data hence show that game progress is related to reading and decoding skills. No significant correlations were found between post- or follow-up reading and decoding fluency and (a) total playing time, (b) the number of sessions played, (c) the number of items seen, or (d) the number of responses given. The latter four GL variables all relate to the duration and the number of learning opportunities that were provided to the student. They do not provide information, however, about the extent to which the student is able to profit from these learning opportunities, his/her reading and decoding level, or his/her ability to translate GL learning into improved real-life reading and decoding skills.

In Table 5a, the intercorrelations between pretest (lightly shaded part) and posttest performance (unshaded part) are provided; correlations at follow-up are listed in Table 5b. In the darkly shaded part of Table 5a, a number of pretest–posttest correlations are presented to investigate relations between pretest reading-related skills and posttest reading and decoding abilities.

Reading and decoding fluency correlate significantly with all tasks at posttest and follow-up, with the exceptions of the posttest lexical decision task, the posttest and follow-up digit span backward, and the follow-up digit span forward. Due to the data not being normally distributed, no factor analyses could be conducted. However, the correlations do show a factor structure, with reading and decoding fluency correlating strongly to each other at posttest and follow-up, being about equally high at both test points. Moreover, all four RAN tasks correlate significantly with each other at all three test sessions. Auditory synthesis correlates with phoneme deletion at pretest and follow-up, but not at posttest. Pretest auditory synthesis and phoneme deletion in general show relatively low correlations with other reading-related skills at pretest, in line with the nonsignificant correlations with GL variables presented at the start of this paragraph.

No significant correlation was observed between digit span forward or backward at any of the three test sessions. This is due possibly to the digit span backward seeming to be relatively difficult for all students regardless of their performance on digit span forward, with mean scores of 0.80 on pretest, 1.33 on posttest, and 1.48 on follow-up for digit span backward, compared to 4.29 on pretest, 4.76 on posttest, and 4.55 on follow-up for digit span forward. Digit span backward only correlates significantly with pretest auditory synthesis and posttest phoneme deletion. We found no significant correlations at follow-up for digit span backward.

Table 4. Spearman Correlations for the GraphoLearn Variables and Reading and Reading-Related Skills at the Pre-, Post-, and Follow-up Tests.

	GraphoLearn						
	Highest level	Playing time	Levels total	Levels per min	Sessions total	Items seen	No. of responses
Pretest							
Auditory synthesis	.360	.107	.136	.153	-.052	.168	.147
Phoneme deletion	.258	.083	.183	.246	.016	.169	.174
Digit span forward	.432*	-.137	.174	.431*	-.181	.015	-.021
Digit span backward	.356	.084	.126	.167	.051	.171	.153
RAN colors	.553**	-.377*	.221	.667**	-.397*	-.033	-.042
RAN objects	.332	.003	.260	.458*	-.090	.129	.132
RAN digits	.362	-.052	.123	.302	-.063	.024	.030
RAN letters	.693**	-.316	.179	.618**	-.415*	-.156	-.181
Number knowledge	.896**	.256	.542**	.574**	.091	.376*	.339
LS knowledge I	.738**	.101	.340	.382*	-.109	.228	.219
LS knowledge II	.658**	.095	.361	.570**	-.038	.178	.179
Posttest							
Reading fluency	.811**	-.155	.321	.670**	-.315	.078	.041
Decoding fluency	.801**	-.193	.321	.679**	-.313	.092	.049
Auditory synthesis	.564**	.126	.468**	.473**	-.002	.314	.287
Phoneme deletion	.406*	-.259	-.076	.392*	-.336	-.091	-.126
Digit span forward	.527**	.026	.266	.399*	.046	.139	.091
Digit span backward	.474**	.122	.153	.190	.014	.134	.104
RAN colors	.590**	-.146	.319	.540**	-.203	.023	.015
RAN objects	.351*	-.050	.313	.474**	-.074	.176	.157
RAN digits	.664**	.105	.495**	.525**	.006	.335	.321
RAN letters	.798**	-.110	.434*	.673**	-.122	.136	.110
Number knowledge	.718**	.181	.342	.487**	.145	.149	.118
LS knowledge I	.489**	.049	.243	.399*	.015	.083	.061
LS knowledge II	.576**	-.196	.139	.486*	-.243	-.029	-.056
Lexical decision	.255	-.277	-.026	.167	-.288	-.094	-.109
Follow-up							
Reading fluency	.798**	.033	.480**	.660**	-.107	.262	.242
Decoding fluency	.848**	.025	.555**	.722**	-.100	.303	.279
Auditory synthesis	.662**	-.114	.344	.543**	-.187	.169	.156
Phoneme deletion	.262	-.338	-.136	.223	-.408*	-.181	-.207
Digit span forward	-.005	-.236	.025	.156	-.149	-.044	-.066
Digit span backward	.387*	.044	.205	.230	-.049	.289	.286
RAN colors	.573**	.090	.515**	.592**	.004	.332	.340
RAN objects	.272	-.100	.217	.264	-.162	.072	.069
RAN digits	.606**	.294	.600**	.531**	.202	.525**	.521**
RAN letters	.689**	.252	.614**	.612**	.162	.426*	.411*

Note. LS knowledge = letter–sound knowledge. RAN = Rapid Automatized Naming.
* Correlation is significant at the 0.05 level (2-tailed) ** Correlation is significant at the 0.01 level (2-tailed)

Table 5a. Spearman Correlations for Reading and Reading-Related Skills at Pretest (light shaded), Posttest (unshaded), Pretest with Posttest (diagonal boxes), and for Posttest (Reading, Decoding) with Pretest (dark shaded).

	Auditory synthesis	Phoneme deletion	Digit span-forward	Digit span-backward	RAN colors	RAN objects	RAN digits	RAN letters	Number knowledge	LS knowledge I	LS knowledge II	Reading fluency	Decoding fluency
Auditory synthesis	.207	.450*	.240	.537**	.287	.191	.273	.214	.625**	.477*	.318	.290	.328
Phoneme deletion	.187	.324	.095	.065	.401*	.456*	.314	.196	.207	.269	.186	.269	.258
Digit span-forward	.532**	.158	.557**	.270	.596**	.320	.176	.351	.403*	.237	.148	.276	.257
Digit span-backward	.084	.375*	.230	.465**	.197	-.067	.406*	.133	.599**	.349	.232	.239	.284
RAN colors	.414*	.347	.460**	.214	.773**	.574**	.421*	.688**	.405*	.241	.156	.542**	.553**
RAN objects	.456**	.310	.312	.019	.608**	.617**	.515**	.457*	.220	.149	.040	.313	.306
RAN digits	.551**	.163	.625**	.137	.590**	.573**	.566**	.435*	.479*	.183	.048	.452*	.465*
RAN letters	.580**	.348	.514**	.197	.603**	.471**	.745**	.670**	.625**	.457*	.243	.761**	.761**
Number knowledge	.538**	.461*	.593**	.517**	.357	.364	.513**	.551**	.800**	.722**	.555**	.695**	.718**
LS knowledge I	.447*	.007	.248	.106	.018	.038	.152	.379	.503**	.215	.605**	.617**	.634**
LS knowledge II	.458*	.378	.393*	.270	.247	.259	.289	.503*	.650**	.622**	.613**	.612**	.578**
Reading fluency	.490**	.453**	.481**	.300	.564**	.428*	.608**	.731**	.601**	.440*	.735**	-	-
Decoding fluency	.506**	.463**	.475**	.256	.555**	.519**	.631**	.792**	.600**	.449*	.707**	.969**	-
Lexical decision	-.034	.086	.257	.117	.057	-.063	.257	.032	.285	.055	.219	.277	.289

Note. LS knowledge = letter–sound knowledge. RAN = Rapid Automatized Naming.
* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Table 5b. Spearman Correlations between Reading and Reading-Related Skills at Follow-up.

	Auditory synthesis	Phoneme deletion	Digit span-forward	Digit span-backward	RAN colors	RAN object	RAN digits	RAN letters	Reading fluency	Decoding fluency
Auditory synthesis	1.000	.364*	.361*	.326	.574**	.370*	.537**	.674**	.710**	.723**
Phoneme deletion		1.000	.263	.156	.230	.168	.067	.304	.512**	.436*
Digit span forward			1.000	.092	.179	.049	-.018	.150	.143	.142
Digit span backward				1.000	.438*	.133	.216	.174	.277	.280
RAN colors					1.000	.505**	.565**	.528**	.485**	.539**
RAN objects						1.000	.633**	.525**	.358*	.434*
RAN digits							1.000	.792**	.676**	.692**
RAN letters								1.000	.835**	.829**
Reading fluency									1.000	.931**
Decoding fluency										1.000

Note. * Correlation is significant at the 0.05 level (2-tailed) ** Correlation is significant at the 0.01 level (2 tailed).

The results in the dark shaded part of Table 5a show a consistent pattern of strong correlations for both posttest reading and posttest decoding fluency with pretest RAN colors and letters, pretest number knowledge, and both pretest letter–sound knowledge tasks. At the $\alpha = .05$ level, both posttest variables additionally correlate with pretest RAN digits.

Regression

We conducted a linear regression analysis to determine whether posttest and follow-up reading and decoding fluency was predicted by progress in the game. Considering the high correlations between reading and decoding fluency at posttest and follow-up (.969 and .931, respectively), the composite scores posttest fluency (combining posttest reading and decoding fluency) and follow-up fluency (combining follow-up reading and decoding fluency) were created by averaging *z* scores and were used as dependent variables in the linear regression models. A similar calculation was performed to create pretest letter-sound (LS) knowledge, combining pretest letter–sound knowledge Parts I and II. Letter knowledge has been shown to be an important predictor of initial reading skills, especially in transparent orthographies (Caravolas, Lervåg, Defior, Seidlová-Málková, & Hulme, 2013; Lyytinen et al., 2008; Winskel & Widjaja, 2007). By adding pretest LS knowledge first to the hierarchical linear regression model, we were able to control for previous letter–sound knowledge. Subsequently, all GL variables (i.e., total playing time, number of playing sessions, total number of levels played, levels played per minute, highest level reached, total number of items seen, and total number of responses given) were added stepwise, in addition to the interaction variables that were created for each GL parameter with the composite score pretest LS knowledge. The strongest predictors (i.e., largest R^2, highest *β*) were included in the final model, as shown in Table 6. Prior to each regression analysis, we checked whether the standardized residuals of the variables included were normally distributed, which they were.

We found a significant main effect for pretest LS knowledge on posttest fluency in the first step of the hierarchical regression analysis ($ß = 0.68$, $t = 4.64$, $p < .001$), but pretest LS knowledge was no longer significant after including the individual variables and their interactions with pretest LS knowledge (see Table 6). In the final model, highest GL level reached and GL sessions total were shown to be significant predictors of posttest fluency, the latter variable having a negative standardized beta. Adding the GL sessions total first, before including highest GL level reached in the final model, resulted in a smaller R^2 change (.114) than the R^2 change for highest GL level reached (.144), and hence did not improve the final model's fit. After controlling for baseline LS knowledge and the highest GL level reached, the total number of sessions played hence became a negative predictor of posttest fluency. Worth noting is that 10 of the 33 students (30%) had completed all 333 levels prior to or by the end of the last (i.e., 50th) GL session, with an average of 37 sessions (range: 27–50) and 7.19 playing hours (range: 5.69–9.49; *SD*: 1.29). Six students (18%), on the other hand, were still struggling with the first 20% of the levels (i.e., Level 66 and below) after a mean of 35 sessions (range: 24–46) and 5.97 hours (range: 4.03–9.11; *SD*: 1.70) of gameplay. Eighteen percent of our sample hence played for several hours over a large number of sessions but still were not able to make substantial progress in the game and reach high posttest fluency levels. As mentioned previously in the correlations section of this paper, the highest GL

Table 6. Linear Regression Equations with Posttest/Follow-up Fluency as the Dependent Variable.

		ß	*t*	*p*-value	*R²*	*F*	*df*	*p*-value
Dependent variable	**Independent variables**					**Full model**		
Posttest fluency	Pretest LS knowledge	.68	4.64	<.001*	**.46**	**21.51**	**1,26**	**<.001***
(Model 1)	Pretest LS knowledge	.22	1.52	.141				
	Highest GL level	.63	4.45	<.001*				
	GG Sessions total	-.41	-4.09	<.001*	**.77**	**26.02**	**3,26**	**<.001***
Posttest fluency	Pretest LS knowledge	-.132	-.51	.614				
(Model 2)	Highest GL level	.486	2.88	.008*				
	Highest GL level x Pretest LS	.540	2.22	.036*	**.68**	**16.00**	**3,26**	**<.001***
Follow-up fluency	Pretest LS knowledge	.67	4.44	<.001*	**.45**	**19.67**	**1,25**	**<.001***
	Pretest LS knowledge	.18	1.11	.278				
	Highest GL level	.70	4.34	<.001*	**.70**	**26.57**	**2,25**	**<.001***

Note. Posttest-fluency = composite variable for posttest reading fluency and posttest decoding fluency. Pretest LS knowledge = composite variable for pretest letter–sound knowledge parts I and II. GL = GraphoLearn. Highest level x Pretest LS = interaction variable Highest GL level x Pretest LS knowledge.

* Significant at the 0.05 level. Pretest letter–sound knowledge was added first to the models presented; all GL parameters were added simultaneously after.

level reached relates to game progress. The sessions total, however, relates to the number and duration of learning opportunities provided to the student, but it does not provide information about the extent to which the student is able to profit from these learning opportunities, the attained reading and decoding level, or the ability to translate GL learning into improved real-life reading and decoding skills. When excluding the duration parameter GL sessions total from the model, a significant pretest LS Knowledge × Highest GL Level reached interaction effect was observed, aside from the significant main effect for the highest GL level reached on posttest fluency (see lower part of Table 6).

At follow-up, a similar pattern of prediction was found for pretest LS knowledge. The pretest LS knowledge variable contributed significantly to the prediction of follow-up fluency by itself, as is shown by the regression results ($ß = 0.67$, $t = 4.44$, $p < .001$; see Table 6). In the final regression model, however, highest GL level reached became the only significant contributor to the prediction of follow-up fluency ($\beta = 0.70$, $t = 4.34$, $p = < .001$). No significant interaction effects were observed for follow-up fluency.

To further investigate the interaction of the highest GL level reached and pretest LS knowledge, we plotted the model predictions in Figure 1 for low ($\leq$ -1) and high ($\geq$ +1) *z* scores on the highest GL level reached and, for continuous standardized data, on pretest LS knowledge. Mean posttest reading and decoding fluency scores (as combined in the composite score posttest fluency) of students with average to above-average pretest LS knowledge (*z* scores > -1) differed significantly between the two GL progress levels. Figure 1 shows that the posttest reading and decoding performance of students with below-average pretest letter–sound knowledge was not moderated by the amount of game progress made. For students with average to above-average letter–sound knowledge, the model described a significant difference in posttest reading and decoding fluency scores between low and high game progress.

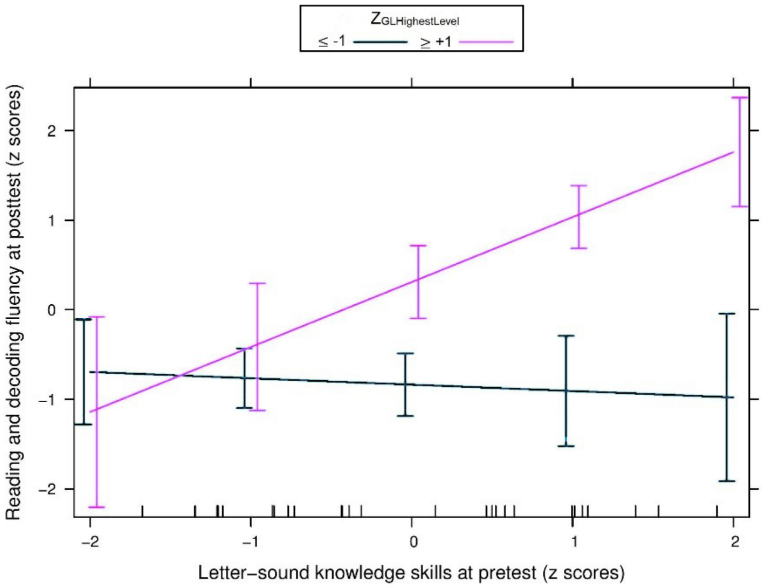

Figure 1. Plot of the pretest LS Knowledge × Highest GL Level interaction effect, with posttest fluency as the dependent variable.

Note. LS knowledge = composite variable for pretest letter–sound knowledge parts I and II. GL = GraphoLearn. $Z_{GLHighestLevel}$ = *z* score GL highest level reached

DISCUSSION

This current pilot study provides a next step in the assessment of GraphoLearn SI as a playful, efficient, and effective intervention promoting reading and reading-related skills in beginning readers. An earlier published study (Borleffs et al., 2018) showed promising results for the compressed version of the game for typical and struggling first-grade readers in a school in the Indonesian city of Medan. In the present study, we tested the main design of GraphoLearn SI with first graders of an elementary school situated on the outskirts of Medan. In our intervention, we aimed at five 10–15 minute playing sessions per week for optimal concentration and automatization of reading-related skills (see also Richardson & Lyytinen, 2014), in line with other GraphoLearn effectiveness studies (e.g., Kyle et al., 2013; Saine et al., 2010).

Although large-scale randomized controlled studies are needed to confirm the effectiveness of GraphoLearn SI, our correlation results show that progress in the game (as measured by the highest game level reached, the total number of levels played, and the average number of levels played per minute) and several of the assessed reading-related skills are significantly related to reading and decoding fluency skills. Our regression analyses point out that, in the present sample, the highest GL level reached was the most important predictor of reading and decoding fluency at posttest, as well as at the 5-month follow-up assessment. We also noted a moderation effect of the highest level reached on the posttest reading and decoding abilities of students with average to above-average pretest letter–sound knowledge: The better the students' knowledge of grapheme–phoneme correspondences at pretest, the larger the effect of game progress was in terms of reading and decoding fluency at posttest. No such significant difference was found between high and low game progress in students with below-average letter–sound knowledge at pretest.

A challenge GraphoLearn SI likely shares with other reading-support methods is that, at the start of first grade, students' initial reading-related skills can vary greatly. The results presented above indicate that students may need a basic level of understanding of grapheme–phoneme correspondences to be able to profit sufficiently from the game. Thirty-one of the 33 first graders we tested in this study come from low- to middle-socioeconomic backgrounds and had attended kindergarten for 1 year only; two students did not attend kindergarten at all. Initial levels of reading-related skills varied greatly on some pretest tasks and may have been, on average, slightly lower in our sample than they might have been among urban first graders from higher socioeconomic families with 2 full years of kindergarten.

As mentioned in the correlation section of this paper, we generally obtained low pretest correlations for both phonological awareness tasks and other reading-related skills. With mean pretest scores of 1.90 and 0.47, respectively, on phoneme deletion and auditory synthesis, these nonsignificant correlations with highest level and levels per minute may have been caused partly by a floor effect. Especially in transparent orthographies in which letters correspond to sounds in a highly predictable way, letter knowledge has been shown to be a powerful predictor of early reading acquisition (Caravolas et al., 2013; Lyytinen et al., 2008; Winskel & Widjaja, 2007). Phonological awareness and reading may be reciprocally rather than causally related (see also Blomert & Willems, 2010; Ziegler et al., 2010), with these skills developing later, contingent upon reading acquisition progress.

Reading acquisition in the SI language has not been studied extensively to date, and some of the tests we used still require further optimization and validation (see also Borleffs et al., 2018; Jap et al., 2017). Other limitations of our pilot study are the relatively small sample size and the fact that all the students stemmed from lower- to middle-socioeconomic families, attended the same elementary school, and all but one spoke SI as their first language. Hence, our results cannot be generalized to the wider Indonesian primary-school population. Large-scale studies gauging beginning readers from various ethnic and socioeconomic backgrounds living in different parts of Indonesia, attending both private and public schools in urban and rural areas, and using active and passive control groups are required to establish the wider effectiveness of GraphoLearn SI in promoting reading and reading-related skills.

Considering that the main design of GraphoLearn SI merely offers players more opportunities to practice the same game content as the compressed version, our research group (see also Borleffs, 2018; Borleffs et al., 2018) questioned the benefit of extended training for students who can attain decoding fluency with regular classroom instruction and the compressed version, that is, playing 1–2 hours spread out over several weeks and sessions. Due to SI's highly transparent orthography (Winskel & Widjaja, 2007), fluency in word decoding is expected to be attained by learning the grapheme–phoneme correspondences and then by putting them together the different sounds of written words (Richardson & Lyytinen, 2014). We researchers (see, e.g., Borleffs et al., 2018) have argued that, for proficient players, the compressed game design may already provide sufficient practice to ensure automatization of decoding skills, whereas struggling players may benefit more from the fuller main design, where the extra practice may help improve their lagging reading and decoding skills.

CONCLUSIONS

The present pilot study evaluating the main GraphoLearn SI design further validates our previous digital reading intervention (see also Borleffs, 2018; Borleffs et al., 2018) by showing once more that a relationship exists between game progress and reading and decoding proficiency, as tested shortly after the last playing session and 5 months later. The present results also revealed that even after an average of thirty-five 10-minute playing sessions, six students from our current sample still showed persistent reading and decoding difficulties.

Various factors may have influenced our results in part. In future research, it may be worthwhile to assess as well other reading-related classroom activities, familiarity with the use of a computer (even though a short training was provided to all students in this study), or familiarity with the type of assessment used (see also Borleffs, 2018). Student motivation also raises an interesting variable to incorporate into future research. During the present pilot study, teachers reported to be pleased with the students' progress and that students generally seemed to enjoy playing the game. Future research also may find that persistently struggling readers require more explicit instructions and feedback than our current game environment provides.

Moreover, such struggling new readers might be at risk of developing serious reading deficits. Future research will need to uncover why some students do and others do not seem to benefit sufficiently from the game and what adjustments are necessary to increase GraphoLearn SI's effectiveness. Potentially, maintaining the same workable playing frequency (i.e., about three 10-min sessions per week) but extending the playing period from 13 weeks to 4 to 6 months may enable the poorer readers to benefit from the game. For those struggling students, 13 weeks of gameplay may have been too short to establish firmly their letter–sound knowledge and to build up their phonological awareness skills (see Glatz et al., 2018, for a similar view).

Furthermore, based on the preliminary but promising results we obtained with GraphoLearn SI so far, another aspect worth investigating is whether this learning tool might have potential as a diagnostic instrument in the early identification of readers at risk of developing serious reading deficits or dyslexia, while simultaneously offering additional learning opportunities (see Borleffs, 2018). Future studies are needed to investigate whether such a digital tool could be integrated into teaching practices and be used effectively to diagnose and support struggling readers. This will depend also on access to suitable equipment and Internet connections at schools, as well as the teachers' attitude toward classroom technology, where cultural and age-related factors may play a role.

The advantages of an online digital game environment are enormous in that, for instance, playing time and progress can be monitored easily, student exposure to a large number of high-quality stimuli is extensive, the player's progress is synchronized across all connected devices, and the game is updated automatically. Still, the lack of availability of sufficient digital devices at school and/or at home may present the most fundamental obstacle in how students gain access to the game (Ojanen et al., 2015; Richardson & Lyytinen, 2014). However, with Internet subscriptions and technological devices becoming more affordable and with the number and spread of digital devices increasing rapidly around the world, this will hopefully become increasingly less consequential in the near future for students in developing countries such as Indonesia.

IMPLICATIONS FOR RESEARCH, APPLICATION AND POLICY

The findings in this study mirror many other investigations of the benefits of early intervention in reading skills development, particularly those employing the GraphoLearn environment. However, our new knowledge about the length of the training period and playing frequency can benefit new readers now and open lines of further research for the future. Specifically, our findings support suggestions for future research to enable struggling readers to similarly benefit from the game. This is bolstered by our statistical evidence regarding specific game variables that contribute to successfully mastering early reading skills, as well as the impact of orthographic transparency on reading acquisition in general. The findings of this paper can assist future researchers in identifying further challenges to young students mastering reading skills in transparent orthographies and can be a stepping stone for the development of additional language versions of GraphoLearn or similar digital-based reading environments.

Moreover, our results support the application of digital game environments for reading skills development within the classroom, in conjunction with teachers' pedagogical plans. Game environments such as GraphoLearn can support teachers in identifying struggling early readers and offer one option for providing the students with evidence-based learning opportunities to practice fundamental reading skills in their respective language. The application of intervention programs such as GraphoLearn can play an important role in preventing illiteracy or alleviating difficulties resulting from dyslexia.

Finally, given the promising results in this study (and others) that early readers benefit from interventions such as GraphoLearn, government-level educators in Indonesia can make a case for investing in these types of programs to boost reading skill before the struggling students fall too far behind their more reading-capable peers.

ENDNOTES

1. GraphoLearn is the registered trademark of the University of Jyväskylä and the Niilo Mäki Foundation for the noncommercial computerized game aimed at learning to read. The game used in this study was programed and owned by the University and employed for research purposes only. GraphoGame, the commercial version of the learning program, is now owned by Grapho Group Ltd. At the time of our study, there was no distinction between the research version and the commercial version, with both available as GraphoGame. However, in this paper, we refer to the learning environment employed in our research as GraphoLearn (no matter what the research version was called in the past) to be consistent with the current research version.
2. This pilot study was conducted in collaboration with the University of North Sumatra (Indonesia) and the University of Jyväskylä (Finland). The general aims of this study, resulting in a doctoral dissertation (Borleffs, 2018), were (a) to gain more insight into orthographic differences between alphabetic languages and their impact on reading and dyslexia, (b) to create a battery of tests to facilitate assessing reading difficulties in young readers of the SI language, and (c) to develop an SI version of GraphoLearn, a computer-based reading intervention, and test its effectiveness among first-grade students.

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