THE RELATIONSHIP BETWEEN PROBLEMATIC SMARTPHONE USE AND THE ACADEMIC PERFORMANCE OF UNIVERSITY STUDENTS

by

Richard Robinette

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Philosophy

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ABSTRACT

To fulfill the explicit mandate of meeting (or exceeding) benchmarks established for the learning objectives associated with programmatic curricular goals, it is incumbent and imperative that the educational process of sharing instructional material with students is not interfered with. However, mobile technology – especially in the form of smartphone use by students while in the classroom during learning activities – may effectively distract attention and focus sufficiently enough to jeopardize both academic performance and the concomitant achievement of learning objectives. The concern is serious and the consequences are significant. This study has attempted to ascertain if the problematic use of smartphones by students can negatively impact the learning experience. The research design plan involved a correlational explanatory approach with a population of students enrolled in a higher education institution. Each participant in a convenience sample from this population completed a Smartphone Impact Scale (SIS) instrument, which was then compared to that student's academic performance. After data collection was completed, the analysis derived from normality assumptions and a correlation matrix revealed a statistically significant association and a medium effect size, which indicates the possibility of an undesirable influence by problematic smartphone use on academic performance. This outcome reinforces similar results obtained by other researchers, and – collectively – suggests that administrators and faculty weigh in these considerations regarding policies related to smartphone presence and extended use during a live classroom experience. Further investigations that feature differing contextual factors would help add greatly to a deeper understanding of this phenomenon.

Keywords: cognitive load, long-term memory, mobile technology, multitasking, smartphone, working memory

Dedication

To my mother, Doris Robinette… thank you for your love and support!

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List of Abbreviations

Bring Your Own Device (BYOD)

Cognitive Load Theory (CLT)

Diagnostic and Statistical Manual of Mental Disorders (DSM)

Doctor of Chiropractic Program (DCP)

Functional Fluid Intelligence (Gf)

Functional Magnetic Resonance Imaging (fMRI)

Institutional Review Board (IRB)

Long-Term Memory (LTM)

National Board of Chiropractic Examiners (NBCE)

Positronic Emission Tomography (PET)

Problematic Smartphone Use (PSU)

Research Question (RQ)

Short Message System (SMS)

Short-Term Memory (STM)

Smartphone Addiction Measurement Instrument (SAMI)

Smartphone Impact Scale (SIS)

Smartphone Impact Scale- Preliminary Version (SIS-PV)

Working Memory (WM)

Working Memory Capacity (WMC)

CHAPTER ONE: INTRODUCTION

Overview

The purpose of this quantitative correlational study is to determine if there is a relationship between problematic smartphone use on the academic performance of university students. Chapter One provides a background for the topics of problematic smartphone use and its effects on attention. Included in the background is an overview of the theoretical framework for this study. The problem statement examines the published span of recent literature on this topic. The purpose of this study is followed by the significance of the current study. Finally, the research questions are introduced, and definitions relevant to this study are provided.

Background

Like a fifth appendage, smartphones are found in the back pocket, purse, or backpack of virtually every student enrolled in a program of study featuring live classroom experiences (Schneider, 2018; Thomas & Muñoz, 2016; Tossell et al., 2015). In fact, the most common places where personal digital devices are seen might be either in a student's hand or on a surface within easy viewing distance. For these adult learners, smartphones are a tool which they are both extensively familiar with and highly reliant upon (Barry et al., 2015; Gallardo-Echenique et al., 2015; Olufadi, 2015). With their varied functional capabilities, the appearance of these technological equivalents of a multiuse tool in an academic setting – along with easy availability for online communication and interactional use in unexpected ways – has escalated over the past decade (Heflin et al., 2017; Kim & Park, 2019; Tossell et al., 2017). Because of their ubiquitous presence in higher education institutions, the problematic use of smartphones in a classroom setting has become a polarizing topic with various stakeholders – students, teachers, and administrators – in the educational environment (Berry & Westfall, 2015; Ellis, 2019; Gallardo-Echenique et al., 2015; Rozgonjuk et al., 2019; Schneider, 2018; Wright, 2016).

Historical Overview

The implementation and use of advanced technology in a classroom environment is not a recent advent. Beginning around the 1980s, schools began to recognize the instructional benefits offered by computer stations for academic purposes by students, and often structured curricular components around this non-mobile technology (Boyd, 2015). Institutional computer-based facilities readily deployed a means of providing course content, testing, and other related instructional capacities that could be used by both faculty and students. The open-door policy for student use of technology continued as these tools evolved, and the inclusion of ambulatory devices (e.g., laptops and tablets) – whether student-owned or school-owned – followed on the heels of stationary computers (Boyd, 2015). The most recent iteration of mobile technology includes smartphones, which are essentially microcomputers with Internet access, as well as telecommunication tools.

Modern smartphones have both computer capacities and additional features (e.g., texting and internet connectivity). The desirable qualities can be deployed in meaningful ways to enhance the learning experience (Barry et al., 2015; Gambo et al., 2017). However, the extended use of the telecommunication and online facilities with smartphones have raised concerns regarding student distraction (Gazzaley & Rosen, 2016), and this has resulted in some schools opting to mandate a variety of policies and procedures, ranging from an encouraged full use of the devices to a total ban on them (Mupinga, 2017; Wright, 2016). Audible notification sounds and recreational diversions are a few of the factors that have been noted to provoke a loss of learning-related focus within an educational setting (Cheong et al., 2016).

The current population which is primarily enrolled in institutions of higher learning consists of two demographic populations. One group is known as Millennials or the Net Generation (born between approximately 1980-1989) and the other is called Gen Z or iGeneration (born between approximately 1990-1999), although there are differences of opinion as to these birth date ranges (Gazzaley & Rosen, 2016). While many have noted that the Millennial group is relatively fluent with mobile devices (Gerber & Ward, 2016; Morreale & Staley, 2016), it may be that their use of smartphones in an academic setting is a two-edged sword, with both imputed benefits for learning and distractions of focus (Abramova et al, 2017; Boyd, 2015; Echenique et al., 2015; Kashou, 2016; Seemiller, 2017).

Positing the perspective that smartphone presence in classrooms could hold beneficial outcomes, a few researchers have noted an array of advantages for students with these devices, such as social connectivity, ready course content accessibility, and entertainment provision for study breaks (Rozgonjuk et al., 2019). Indeed, the social networking afforded by smartphones could be deemed as an advantageous interaction that produces physical, mental, and emotional health enjoyments (Ellis, 2019). Aside from social interaction or amusement purposes, it has also been suggested that what is perceived as problematic smartphone use (PSU) with students may be more due to increased activity with Internet searches via their devices as a way to offset short-term uncertainty anxiety, rather than indicating a negative set of behaviors (Rozgonjuk et al., 2019). In fact, within the context of a more collaborative instructional setting, one study proposed a positive correlation between the use of selected smartphone apps and student engagement, although the authors expressed reservations as to the level of critical thinking demonstrated with work composed by means of mobile technology device keypads (Heflin et al., 2017).

Regarding the potential for the distraction offered by smartphone use to be detrimental in a learning environment, the biggest offenders tend to be due to unrestrained messaging (e.g., both the sending and receiving of texts or similar communications), relentlessly accessing social media (e.g., Facebook posts), and compulsive entertainment viewing (Schneider, 2018). For many who are studying the phenomenon of smartphone presence within an educational environment, the belief by many students in their ability to successfully multitask between conducting these off-task activities and also paying attention to an instructional presentation is a significant cause for concern (Barry et al., 2015). Whether this belief is validated by cognitive psychology or not is a salient question.

Theoretical Discussion

Cognitive psychology has contributed a number of theoretical foundations to education and learning (Kandel, 2014). These include the overarching concept of information processing theory (Schunk, 2016), short-term memory model (Atkinson & Shiffrin, 1968), working memory theory (Baddeley & Hitch, 1974), cognitive load theory (Sweller, 1988), and Hayles (2007) hypothesis regarding attentional tendency differences between generations. Information processing theory features an amalgamation of elements related to the process of learning, particularly as these involve the memorization of instructional material for retention and recall within education, and factors that can impact these functions (Schunk, 2016). These five theoretical constructs (i.e., information processing, short-term memory, working memory, cognitive loads, and attentional tendencies) form the framework of this study.

Within information processing theory, as it applies to memorization, attention is one of the major tenets (Schunk, 2016). It has been noted that for learning to take place, conscious attention will influence rehearsal (Schunk, 2016). Rehearsal includes various tactics used to transfer information from working memory (WM) into long-term memory (LTM), which then encodes the learned unit of information (Craik & Watkins, 1973; Schunk, 2016). Demonstrated successful methods of rehearsal include repetition (both simple and cumulative), note-taking, and text markup (Neer, 2015). The consequences of disrupted attention during information processing (i.e., any factor that thwarts data movement from WM to LTM) can easily jeopardize learning, with a roster of corresponding subsidiary issues (e.g., lower grades, incomplete comprehension of material, or altered affective behavioral function). Regardless as to the extent of dissonance that mobile phones can bring into the learning arena, the tempting and ready availability for classroom-unrelated activities proffered by these telecommunication instruments adds at least one more distracting element into the learning mix, generating decreased attention to – and thus retention of – instructional information.

The root of the concern is almost certainly connected to potential disruptive influences (from problematic smartphone use during a presentation of instructional material) causing breaches with attention. Attention fragmentation interrupts a smooth transition of data items housed in WM to LTM, thus adversely affecting overall learning ability by students (Chen et al., 2018). Within the concepts of information processing theory, any disturbance that negatively affects conscious attention – such as problematic smartphone use (especially for non-academic purposes) – is very likely to impede learning (Levitin, 2014; Schunk, 2016). Cognitive load theory (CLT) – as initially outlined by Sweller (1988), and further refined by Paas and Van Merriënboer (1994) – is a correlate to the WM postulate. The essential model stipulates that an extraneous factor (e.g., instructional methodology) can cause cognitive functions to lose attentional focus on a learning task and instead experience an elevated awareness of the distraction (Sweller, 2016). With WM constraints and CLT considerations in place, if student distraction is impacted by problematic smartphone use (particularly during classroom events), then subsequent LTM recall would be negatively affected and academic performance likely impaired (Sweller et al., 2019).

Problem Statement

It is true that mobile technology has brought about many positive upgrades to society in general (e.g., greater ability to maintain contact with family and friends), however the attention-grabbing ability of these tools has also acted to create distractive tendencies with users, sufficient enough to produce an absent presence. In this mode, the smartphone owner may be in physical proximity, but completely unaware of the surroundings because he or she is mentally caught up in the technological realm generated by the device (Aagaard, 2016). While this describes one form of distraction, there can be other manifestations as well, and – in the classroom – these all can be conducive to a loss of attention on the learning activity taking place, along with a shifting of focus onto some task at hand being mediated via one's smartphone (Gazzaley & Rosen, 2016). The presence of diminished concentration on an educational presentation in favor of problematic smartphone use (e.g., checking or sending a text, playing a game, or posting a social media update) by students is common and frequent (McCoy, 2016).

The most salient concern related to the issue of problematic smartphone use (notably while in a classroom setting) is the postulated lower academic performance that transpires in the wake of distracted attention, primarily due to the diminished retention of informational material being delivered through an educational presentation (Aaron & Lipton, 2018; Amez et al., 2019; Kates et al., 2018; Lepp et al., 2015; Samaha & Hawi, 2016; Turkle, 2015). Some few studies, featuring varied approaches to this problem, have reported results which seem to corroborate the impression that the distraction generated by mobile technology in a learning environment is notably conducive to a fragmented focus and subsequent reduced academic performance (Aaron & Lipton, 2018; Bai et al., 2019; Beland & Murphy, 2016; Felisoni & Godoi, 2018; Giunchiglia et al., 2018; Junco, 2015). Over the past decade, only a limited number of researchers have explored the ramifications of problematic smartphone use during classroom activities in conjunction with either multitasking (Ainin et al., 2015; Bellur et al., 2015; Demirbilek & Talan, 2018; Ellis et al., 2010; Moisala et al., 2016) or attentional distraction (Lau, 2017; Kuznekoff & Titsworth, 2013). Only one notable investigation – which involved consumers, not students – looked at whether solely the viewable proximity of one's quiet smartphone (i.e., powered down and thus without audible or visible distraction) might provide sufficient distraction to lower cognitive abilities during a learning event, as measured by subsequent testing (Ward et al., 2017).

If a possibility exists that problematic use of smartphones by students (or even the mere presence of mobile devices) within a learning environment contributes to a substantial amount of distraction, then there is a corresponding need to conduct further research regarding this concern. It may be that problematic smartphone use could be associated with diminished retention of curricular content and – by extension – result in an overall lower academic performance. The problem is that the literature has not completely addressed whether the problematic use of smartphones (especially during class-time) is correlated to the academic performance of university students.

Purpose Statement

The purpose of this quantitative study was to examine if a significant relationship exists between problematic smartphone use (PSU) and the academic performance of higher education students. A correlational research design was used to explore the possibility of an influence on academic performance by the behavior associated with PSU. The impact of problematic smartphone use (as determined by Smartphone Impact Scale scores) was the independent variable (Pancani et al., 2019), and academic performance (as determined by averaged numerical grades) was the dependent variable.

Academic performance by a student can be defined as the evidence of scholastic achievement that is measured by some type of scale, typically by using selected assessment data (e.g., formative or summative) and other means (Martin Sanz et al., 2017; York et al., 2015). One evaluative scale for academic performance within institutions of higher education is a student's averaged numerical grade. Thus, academic performance (by the proxy of that student's averaged numerical grade) constitutes one measured variable, in that it may be correlated to another variable (Rovai et al., 2014).

A convenience sample of university students was obtained from the population of a small private higher education institution in a southwestern state. The study participants from this sample responded to the SIS survey questions to ascertain levels of PSU (i.e., the independent variable) and the academic performance (i.e., the dependent variable) of these participants was represented by their averaged course numerical grades. Analysis of these data were conducted to determine if a statistically significant association is evident between the independent variable and the dependent variable.

Significance of the Study

Many university students are either unaware of the possible repercussions from problematic smartphone use during classroom activities, or else minimize the seriousness generated by loss of focus due to distraction stemming from engaging with their personal digital devices while attending an instructional event. (Echenique et al., 2015; Olufadi, 2015; Santos et al., 2018; Thomas & Muñoz, 2016; Tossell et al., 2015). This study was intended to add continued research with whether an association exists between problematic smartphone use by students and academic performance.

Further insight into the possibility of smartphones being effectively deployed as educational tools – even if in a limited capacity – can be of great value to a number of instructors in higher education (Kim & Park, 209). On a broader scale, any indications that strongly suggest a correlation between smartphone policies in an educational setting and academic performance would be important to administrators when determining how best to establish a campus-wide rule related to allowing these devices in the classroom or not (Gao et al., 2017). If there are indeed valid concerns as to any adverse impacts associated with the off-task use of smartphones while in class or studying, students would be well-advised to be aware of these findings, especially if they are not constrained by education facility policy and are left to make personal decisions with which path to take. Additionally, the informative contributions derived from this study will be valuable to further the theoretical insights found within cognitive psychology, especially how these relate to the possible role played by smartphones with multitasking and distraction, along with any impacts that may be evident to academic performance.

Because most adult learners in a university setting are in the Millennial or Gen Z generation demographic, it has been suggested that further studies are necessary for a better grasp on Millennial and Gen Z behavior. (Chong et al., 2015; Reio & Hill-Grey, 2014). The population targeted by this investigation consisted predominantly of Millennial and Gen Z students in a higher education setting, and thus contributes to this need as it relates to problematic smartphone use behavior by these two generations.

Educational settings have attempted to wrestle with the concern of potential problematic smartphone use by students in different ways: some embracing mobile technology and maximizing its instructional advantages (and possibly dismissing any disruptive elements), while others hold differing perspectives as to any negative effects on focus and concentration (Mupinga, 2017; Wright, 2016). Regarding the former, some schools have felt that smartphone employment held beneficial applications, if care was taken for generating a suitable setting to maximize the proper utilization of mobile technology in a school (Karataş, 2018). Essentially, this view states that the negative aspects of problematic smartphone use in the classroom (e.g., loss of focus) should be accepted as associated features of an otherwise useful educational tool (Karataş, 2018). As to the latter, there is minimal literature that addresses concerns related to the problematic use of smartphones reducing student engagement and attention during class, thus fragmenting the transition of information from WM to LTM and the ability to learn more effectively. This study explored the relationship between problematic smartphone use and academic performance, and therefore adds further insight into this area of uncertainty.

The use of smartphones by students in schools has expanded more rapidly than educators have been able to keep up with (Pynos, 2016). For at least some of these students, the extended engagement with the medley of useful features (e.g., connection, communication, and safety) offered by mobile technology has indicated tendencies toward what has been deemed smartphone addiction and dependence (Gutiérrez et al., 2016). Apparently, it is at least not unusual for Millennial or Gen Z students to feel distressed when their smartphones are not in immediate proximity (Russo et al., 2014). The device-dependent tendencies elicited by smartphones and their capabilities may be a driving force behind off-task behavior by students during educational activities (Olufadi, 2015). While these considerations may merit a more granular inspection, this study inquired into a broader range of scales related to problematic smartphone use by university students.

Considering the abundant presence of higher education students and the concomitant persistence of mobile technology – as both a vehicle for learning, as well as a possible impediment to focus and engagement – questions regarding the full nature of problematic smartphone device use in a classroom setting beg a deeper investigation. More information is needed on this topic, because the relentless pace of mobile technology change is unabated (Barry et al., 2015; Kashou, 2016), and the potential for associated effects on academic performance is still far from certain (Tossell et al., 2015). Thus, there is a pressing urgency for further studies to more accurately indicate the relative impact of problematic smartphone use within an educational setting, and if there is any relationship with academic performance.

Research Question

RQ1: Is there a significant relationship between problematic smartphone use, as measured by the Smartphone Impact Scale, and the academic performance of university students, as measured by their averaged numerical grades?

Definitions

1. *Mobile technology* is defined as personal digital devices, often referred to as smartphones, mobile phones, mobile devices, and similar portable tools that provide telecommunication means, computer functions, and online access (Aaron & Lipton, 2018).
2. *Academic performance* is defined as the relative degree of scholastic achievement by students (individually and collectively) enrolled in an institution of higher learning, and can be measured by a student's averaged numerical grade, which is considered to be a valid benchmark (York et al., 2015).

CHAPTER TWO: LITERATURE REVIEW

Overview

To investigate the issue of smartphones and academic performance, a systematic review of the literature was undertaken. This chapter will present a review of the current published literature on various aspects of the topic of study. The first section will address the theories related to academic performance, including working memory and cognitive load. Much of this information stems from growing recognition of the important contributions from educational neuroscience (Zadina, 2015). Although the range of what constitutes the field of educational neuroscience is extensive (Schrag, 2011), the discoveries are of great value for teaching (providing insights with student behavior), instructional methodology (offering new ideas for better classroom strategies), and learning institution administration (suggesting improvements with curricular design). The second section will initially provide a synthesis of recent published literature related to smartphones in educational settings, generational considerations, and administrative policies. Next, important factors related to the presence of smartphones in the classroom are reviewed, including smartphone addiction concerns, multitasking, and possible adverse effects on academic performance. At the conclusion, a significant area that is unaddressed in the literature will be noted, and a rationale for conducting the current investigation is offered.

Theoretical Framework

Subsumed beneath the banner of information processing theory, there are two primary theoretical mechanisms that underpin the premise of potential student distractions during classroom activities – especially those in the form of smartphones – resulting in measurable differences with academic achievement. Working memory (WM) theory is the prevailing model in place, and cognitive load (CL) theory is an important tangential and complementary conjectural argument. This section will first provide an overview of information processing theory, as it pertains to education, then present elements of educational neuroscience, and finally review the development of WM and CL theories.

Information Processing Theory

Information processing theory is a collective term comprised of different perspectives related to learning derived from cognitive psychology (Schunk, 2016). Within the context of education, the work by Atkinson and Shiffrin (1968) stands as a pivotal source for concepts related to the role of both short-term and long-term memory. Building on this foundation, Baddeley and Hitch (1974) expanded the Atkinson-Shiffrin postulate into a more refined model termed working memory (WM) theory. Tangent to WM theory is the concept developed by Sweller (1988) known as cognitive load (CL), which proposes that different factors could negatively impact the conversion of WM into long-term memory (LTM). Thus, the overarching information processing theory consists of two important components (i.e., WM and CL theories), and both can be influenced by attentional distractions, which could – by extension – affect information retention and recall by students when assessed.

When information processing theory is applied to learning, attention is considered to be one of the major tenets (Schunk, 2016). Thus, the consequences of disrupted attention during information processing (i.e., any factor that thwarts data movement from WM to LTM) can easily jeopardize learning, with a roster of corresponding subsidiary issues (e.g., lower grades, incomplete comprehension of material, or altered affective behavioral function). Regardless as to the extent of dissonance that smartphones may bring into the learning arena, the tempting and ready availability for problematic activities proffered by these devices adds at least one more distracting element into the learning mix, presumably generating decreased attention to – and thus retention of – instructional information.

Educational Neuroscience

The varied realms of education, cognitive psychology, and neurology have converged into an unfolding amalgam that some have termed as educational neuroscience (Brookman-Byrne & Thomas, 2018; Tandon & Singh, 2016; Thomas et al., 2019). Although other names for this emerging field have been proposed (e.g., neuroeducation), educational neuroscience has become the predominant choice for most authors and researchers (Thomas et al., 2019). In relation to concerns within information processing theory and the effects of distraction on attention, educational neuroscience holds some useful points of applicability, especially in the direction of memory (both working and long-term) and learning.

Information Processing Interference

Due to advances in different components of educational neuroscience, more is now known about the human brain than at any time prior to the advent of modern science. One of the more humbling items with this understanding is the realization of the brain's susceptibility to memory lapse, caused by interference to information processing (Gazzaley & Rosen, 2016). The two primary sources of interference are brought about through what Gazzaley and Rosen (2016) noted as either distractions or interruptions.

While there is discernible overlap between these two avenues of interference with the processing of information (and thus also impeding optimal learning via disruption of WM to LTM), there are some distinctions. Distraction can take place from either internally-mediated occurrences (e.g., loss of focus away from thinking about something other than the object of attention) or externally-mediated circumstances (Gazzaley & Rosen, 2016). Interruption also may happen, due to both internal and external events that provoke a desire to attempt what is known as multitasking, but which is referred to more in cognitive neuroscience as task alternation or task switching (Schmidt et al., 2020). Regardless as to the term used, multitasking or task switching, whether attempted exclusively internally (i.e., striving to adequately maintain an alternating focus on two – or more – thought processes) or externally (i.e., trying to conduct both mental and physical activity to accomplish two – or more – operations), has been shown to negatively impact cognitive information processing speed (Lin et al., 2016).

The Dopamine Reward System

The question arises as to what may be causing these mechanisms of information processing interference. Again, certain fields of study which comprise educational neuroscience have noted cognitive tendencies that are suspected to predispose the human brain toward activities more conducive to distraction than focus. One factor involves a neurotransmitter substance known as dopamine. Dopamine is a chemical produced by a relatively small number of interneurons (i.e., cells that make up the neurologically functional portions of the brain and spinal cord), and – like many neurotransmitters – it has the ability to transmit messaging signals between the interneurons (Shier et al., 2019). One of the main functions provided by dopamine presence is to select and allow only certain messaging signals moving through the brain to be acted upon (Berns, 2005).

However, the importance of dopamine production is with its now-understood role as a facilitator for generating the awareness of a non-localized pleasurable sensation (i.e., one originating within the brain itself, not derived from any peripheral nervous system receptors) when select cognitive actions take place (Berns, 2005). This ability by dopamine to enable a mental reward in response to certain activities is thus a significant determinator as to why the human brain tends to conjure situations that produce a dopamine-induced sense of pleasure. The reason appears to be the pursuit of added information, for the larger purpose of establishing a perceived higher degree of predictability regarding the psychosocial interactions that the individual engages in (Berns, 2005).

The veracity of this proposal is supported in the relevant scientific literature that would broadly pertain to educational neuroscience. When the human brain successfully acquires information (particularly of an unforeseen nature), whether related to possible future events or unfolding current activities, it is duly rewarded with an experience of pleasure (courtesy of dopamine) when such is achieved (Bromberg-Martin & Hikosaka, 2009; Takahashi et al., 2017). This system of chemical reward in exchange for obtaining new information is theorized to be an evolutionary adaptation of what would be earlier primal recompense for the acquisition of new awareness with an improved survival circumstance, such as a previously unknown water or food source (Bromberg-Martin & Hikosaka, 2009). Although still undetermined, it would appear that the reverse may also hold validity, meaning the human brain could receive dopamine-generated pleasure from the acquisition of information constituting a more aversive nature (Matsumoto et al., 2016).

While the dopamine reward system would appear to favor more optimal information processing, it may be that the receipt of pleasure rewards for securing varied types of knowledge items could be a source of interference with the WM to LTM mode of learning (Gazzaley & Rosen, 2016). This circumstance is suggested by a scenario in which the suitable processing of information being delivered by an educational presentation is potentially undermined by a student’s attempt to conduct task switching simultaneously between the on-going instruction and his or her active engagement with information being accessed via the student’s smartphone.

Theoretically, the dopamine reward system should be facilitated by either one of these knowledge acquisition activities. However, there is a factor that could trend the student more toward the smartphone-derived information gathering, instead of from the educational presentation.

Novelty and the Dopamine Reward System

One of the more salient features linked to the dopamine reward function is that there seems to be an increased response of pleasure with what could be termed as novel information discoveries (Costa et al., 2014). Ironically, it may be that in order to better determine predictability, the pursuit of novelty is an embedded component, and the procurement of fresh and even unpredictable information – whether holding positive or negative value – will profit with a pleasurable reward by means of the dopamine system (Berns, 2005). On a more concerning note, there may be a connection between the dopamine-mediated pleasure response for novelty pursuit and addictive tendencies, both with substance and behavior (Van Holst et al., 2018; Wingo et al., 2016).

The concept of the human brain gathering knowledge as to the external environment for concrete primitive needs (i.e., sustenance), then experiencing a dopamine system-mediated reward for the achievement, would seem to be a precursor of the fairly recently explored – and notably more sophisticated – discoveries with the model. It is reasonable to subscribe to the idea that the successful collecting of information for abstract needs (rather than merely appetitive concerns), for the purpose of developing better predictability as to one's circumstances (especially for social interaction) would be a more modern iteration of the dopamine reward function (Bromberg-Martin & Hikosaka, 2009). In fact, it may be that this apparently evolving award-for-information attainment design, particularly when the details obtained are unfamiliar ones, is the basis for the cognitive feature known as curiosity.

Curiosity and the Dopamine Reward System

Curiosity is considered by one of the constituent fields within educational neuroscience to be a psychological drive that is characterized by a cognitive interest in – and active engagement with – the exploration of unfamiliar material (Kidd & Hayden, 2015). As such, curiosity would seem to be an evolutionarily-recent impetus that promotes information, gathering for the purpose of reducing uncertainty (Bromberg-Martin & Monosov, 2020; Cervera et al., 2020; Van Lieshout et al., 2020). Taken together, the development of what apparently began as a primarily basic needs driven mechanism of dopamine reward for the successful acquisition of useful survival information, has advanced into a much more complex set of neurological activities. Assuming such, the refinement of amassing informative data for more cognitive-based purposes – and receiving the same dopamine pleasure experience – may have expanded further. Although not always categorized as a curiosity-based phenomenon, the process whereby individuals actively seek what is termed non-instrumental information is also accorded a comparable return of chemically-induced satisfaction (Berns, 2005; Bromberg-Martin & Monosov, 2020). Non-instrumental information has been defined as knowledge items that do contribute to mitigating uncertainty, but do not directly hold evident usefulness for future consequences (Brydevall et al., 2018).

Attention and Memory

Despite the obvious advantages provided by the dopamine reward system for the acquisition of information, whether of relatively immediate instrumental utility (either appetitive or cognitive) or potentially valuable for future situations (i.e., non-instrumental utility), there may be a psychoneural price to pay. Much of the material gathered by the human brain's cognitive abilities (and rewarded by the dopamine system) is directed toward decision making, which is the process of determining a particular action to undertake out of a group of other possibilities, by using some form of tactics and within a set of standards (Wang & Ruhe, 2007).

Better understanding about decision making has been generated by educational neuroscience, and its role with facilitating the optimal and targeted use of the information (both appetitive and cognitive) that was collected by the human brain. Arguably one of the most salient is known as selective attention, which is also often referred to as attentional filtering, and considered to be a major aspect of cognitive control (Lavie et al., 2004; Mackie et al., 2013; Treisman, 1964). Selective attention is characterized by its capacity to shift focus from one target being monitored to another, either because of a need to concentrate information gathering on an item of biological importance (e.g., an issue of survival) or due to imputed value with an article of non-instrumental interest (Gazzaley & Rosen, 2016; Levitin, 2014). This a necessary and desirable attribute to conduct the task of decision making, and the ability to refine it can improve daily function (Schmicker et al., 2017).

However, this selective attention function can be compromised by cognitive interference, whether intentional or not (Salo et al., 2017). In various fields of educational neuroscience, the term most used to indicate this circumstance is known as divided attention (Middlebrooks et al., 2017; Weeks & Hasher, 2017). A major source of causation with divided attention can come in the form of environmental diversions (e.g., audible conversations between individuals who are in proximity to the person attempting to execute selective attention) or by means of other demands for focus (e.g., smartphone notifications), which all can readily fragment efforts to maintain focus on a selected object (Gazzaley & Rosen, 2016; Levitin, 2014; Salo et al., 2017).

Another aspect related to attention is the understanding that there are limited cognitive resources available, which could be jeopardized by overload from either excessive task switching or by information processing demands (Craik et al., 1996; Craik et al. 2018; Salo et al., 2017). The concept of limits with neural functioning (e.g., WM to LTM) is often expressed as cognitive load theory, and there are several applications of this perspective within education, memory, and learning (Buchin, 2019; Lavie, 2005; Middlebrooks et al., 2017). Thus, the role played by selective attention to a designated task, along with any deflection from doing so that is brought about by extraneous and competing candidates, is one that can readily diminish ideal levels of memorization and learning.

The component fields related to cognition, psychology, and neurology greatly contribute useful understanding that can be integrated with what is known about learning to produce an overarching study known as educational neuroscience. The value derived from various studies found in this area of exploration manifests with insights into information processing theory and subordinate concerns, including the dopamine system and attentional functions. In turn, other theories on the relationship between working memory and long-term memory, as well as cognitive load theory, hold importance with the role that these play in learning and education.

Working Memory Theory

The threads of exploration into how the human brain processes memory, as well as tangential considerations (e.g., factors that can provide either constraints or augmentations) include the short-term memory limits suggested by Miller (1956) and the relationship model of short-term memory to long-term memory proposed by Atkinson and Shiffrin (1965). Although different aspects of these initial forays are still in dispute, the majority of what has unfolded from these seminal sources continues to be expanded upon (Adams et al., 2018; Cowan, 2001;

Malmberg et al., 2019).

Baddeley and Hitch (1974) are the theorists who revamped the Atkinson and Shiffrin (1965) hypothesis of short-term memory (STM) into a more elaborate model that involves the term they chose, which is known as working memory (WM). Cognitive psychology had up to that time posited STM to be a critical element with the process whereby the human brain is able to retain information in a long-term memory (LTM) storage, but little of substance had been discovered which shed more light on the STM function (Baddeley & Hitch, 1974). However, experimental evidence generated by the authors demonstrated significant levels of validity with their multicomponent revision of how STM, now labeled WM, impacts the transition to LTM (Baddeley, 1998). Corroboration of what is often called the Baddeley Working Memory model was provided by investigations that involved positronic emission tomography (PET) and functional magnetic resonance imaging (fMRI), which indicated even further possible fractionation with the proposed operational components (i.e., WM, LTM, and a central executive) then in place (Baddeley, 1998).

A fuller picture of the Baddeley working memory theory and its multicomponent framework continued to unfold, and eventually took the form of WM being first couched in either of two slave systems, known as the visuospatial sketchpad (i.e., for graphic-related information) and the phonological loop (i.e., for language-related information), and then transitioning into LTM (Baddeley, 2002). Further functional components were noted by Baddeley (2003), and one of these became known as the central executive, whose involvement with processing the two subsystems into LTM arguably has a priority (albeit a still mostly unknown one). More recently, this three-component model (i.e., the two slave systems and the central executive) has had a major addition, called the episodic buffer, which provides a limited-capacity interface between the other three portions and LTM (Baddeley, 2010). Besides images and language, the working memory model has extended its sensory spectrum to include haptic input (through the visuospatial sketchpad) and expanded the phonological loop for music, sounds, and lip reading (Baddeley et al., 2011).

The conceptual map supplied by the now-elaborate Baddeley working memory theory has helped consolidate the idea that when learning, novel information – whether linguistic or graphic – is a fluid and tenuous feature (Baddeley, 2012), thus the capacity for its encoding into schemas within LTM can be impacted by disruptive sensory competition. Another potential factor that can affect learning is the relatively limited amount of information able to be held in short-term storage by the episodic buffer (Baddeley, 2012), which could also be influenced by attentional fragmentation. Deeper discussion with both of these aspects is embodied within, and expanded upon by, the cognitive load theory.

Cognitive Load Theory

Sweller (1988) first focused attention on the concept of cognitive loads while considering the role of constraints that could affect learning, particularly the mechanisms of selective attention and cognitive processing capacity. Cognitive load theory (CLT) has both garnered additional respectability and continued to evolve since Sweller's (1988) initial conjectural publication. One notable element is the incorporation of schemas, which are considered to be cognitive constructs that – once formed from previous information acquisition – allow new learning to be attached to them easier by greatly lowering WM loads (Sweller, 1994). However, if cognitive loads are elevated, learning will be challenged, no matter whether these loads are due to extraneous sources (e.g., ill-advised instructional methodologies) or intrinsic (e.g., complicated teaching material), and often a combination of the two (Sweller, 1994; Sweller et al., 2016).

Further ramifications with CLT include acknowledgement of the multidimensional nature that comprises the concept, and the need for educators to be attentive to extraneous factors (e.g., instructional approaches) during the presentation of information for learning (Paas & Van Merriënboer, 1994). A very salient aspect with this was outlined by Lavie et al. (2004), who noted that attentional control is actively recruited against low-priority competition, but at the expense of WM. The net effect is then a tendency for cognitive functions to lose focus on a learning task and instead experience an elevated awareness of distractions. Smartphones can readily be cited as an example of “irrelevant distractors” (Lavie et al., 2004, p. 339). Moreover, the current accepted set of components in CLT – consisting of extraneous cognitive load (i.e., instructional mode and physical environment variables), intrinsic cognitive load (i.e., relativistic learning material difficulty), and germane cognitive load (i.e., the facilitation of novel learning by inherent cognitive processes) – are all in play with their own influences on the overall process of shifting WM into LTM during educational activities (Moreno, 2006). The corollary to the impact of these factors on WM is that circumstances which “reduce extraneous sources of load lead to increased learning because learners are able to use the freed resources to engage in germane cognitive activities” (Moreno, 2006, p. 172). Hence, fewer disruptive sources within a classroom setting should enable more optimal learning.

Another mostly unexplored aspect of CLT is the possible impact of both motivation and emotion as these relate to learning. One recent literature review tentatively suggested that there is reason to suspect a previously unknown influence by cognitive loading on the efficacy of both the presentation of instructional material and motivational levels experienced by learners (Feldon et al., 2019). The role played by problematic smartphone use as a potential contributor to increased cognitive loads, thus having a bearing on reduced motivation with learning – and ultimately academic progress – may be a tenuous, yet viable one.

An additional effect that is speculated to be brought about by cognitive loading is the reduction – or even exhaustion – of sufficient mental resources to adequately support WM function after sustained cognitive effort has been expended, especially with closely grouped learning activities (Chen et al., 2018). While the primary focus was on elevated cognitive loads that were generated by massed learning, it is conceivable to envision a similar circumstance taking place while task switching between a significantly challenging educational presentation and smartphone use. If this is indeed valid, then a case could be made with the premise that conducting off-task operations with a smartphone while simultaneously attending a class is likely to raise cognitive loads and dangerously expend WM capital accordingly. Whether habitual conduct such as this could eventually affect academic performance is uncertain, but based upon what is currently known about working memory and cognitive load theories, the potentiality is concerning.

With the continued acceptance of CLT as a viable conjecture, the primary aim with the insights provided by this framework is to help ensure better instructional approach (Sweller, 2011; Sweller, 2015). In particular, when there is a split-attention effect due to the presence of two or more simultaneous information streams, it produces an extraneous cognitive load and subsequent learning challenges (Sweller, 2011). In a refined aspect of this line of thought, distractions occurring within the physical educational setting could be a causal factor that can produce increased cognitive loads (Choi et al., 2014). Prior considerations about the physical learning realm with regard to CLT had not received much notice, but Choi et al. (2014) held a perspective that posited a significant role by the educational environment "as a determinant for learning and performance" (p. 238). Problematic smartphone use in a classroom or other educational setting is a ready example of a physical learning setting determinant.

The combined merits of both Baddeley's working memory theory and Sweller's cognitive load theory are of primary importance when applied to concerns associated with learning and education (Paas & Ayres, 2014; Sweller et al., 2019). Over the years, many researchers within the various fields that comprise educational neuroscience have noted the integrated relationships between working memory (both when optimized and compromised) and the process by how information is retained in long-term memory (Cowan, 2014; Paas et al., 2003; Sweller, 2016). Finally, the role played by attention (i.e., whether it is selective or divided) can frequently be the deciding factor as to the relative success of the information processing system, and this is obtained by the degree of shifting from working memory to long-term memory (Cowan, 1988).

Deep Attention and Hyper Attention

While not explicitly within the realm of either working memory theory or cognitive load theory, Hayles (2007) pointed out a generational shift of attentional tendency that is predicated on the effect of burgeoning technology, and how such may have influenced the cognitive abilities of those students who grew up with – and continue to rely heavily on – technologically-based diversions and utilities. The two cognitive modes proposed by Hayles (2007) are:

- Deep attention, which denotes concentration that can be harnessed on a focal point (e.g., a book) for extended periods of time, and also includes the ability to ignore extraneous stimuli.

- Hyper attention, which features a strong proclivity for a rapidly changing mental direction between multiple foci, experiencing numerous simultaneous sensory inputs, elevated levels of stimulation, and a corresponding difficulty with enduring what is deemed as boring.

While both of these attentional capacities likely served differing needs in an evolutionary context, the relatively recent advent of personal entertainment technology has appeared to trend the cognitive preferences for many students with this background to now bring hyper attention characteristics into the educational environment (Hayles, 2007). Smartphones and their problematic use in the classroom could be suspected as co-conspirators that further reinforce the preference tendencies by those students toward hyper attention qualities (e.g., easily bored, a need for continuous stimulation, and wanting several sensory inputs all at the same time).

As can be seen, there appear to be strong relationships between cognitive load theory, working memory deficits, and the production of long-term memory storage (Paas & Ayres, 2014). Both WM and LTM hold demonstrably critical gravity in the context of education, and CLT is a major acknowledged consideration with instructional design and informational presentation approaches. With the validation achieved by decades of ongoing research, both WM theory and CLT continue to explore further areas of importance with the impact of these criteria on learning, especially as education moves into yet more novel directions (Mavilidi & Zhong, 2019). One of those paths of exploration certainly includes the ramifications with how problematic smartphone use might affect working memory and cognitive loads, thus potentially having negative influences on academic performance. Additionally, if the idea about burgeoning levels of hyper attention mode with young adults is valid, problematic smartphone presence (particularly in the classroom) could hold serious significance with student achievement (Hayles, 2007).

Related Literature

Through the efforts of Baddeley (2018) to better elucidate the limitations associated with WM, and the process of information transfer to LTM within educational efforts, much has been garnered as to how this process appears to work. Tied to the WM theory, in an applied instructional context, is the contribution by Sweller (2011) as to the constraints imposed by cognitive load on the WM to LTM transfer during classroom learning activities. These well-studied and widely-accepted theories of learning indicate that optimal educational efforts should occur when extraneous cognitive load is minimized. In addition, subsequent evidence of this postulate can be provided by respectable academic performance in the wake of successful acquisition by a student of curricular-related information. However, this simple-appearing process has a number of contributory elements that can potentially thwart attempts to reduce extraneous cognitive load, and these may appear in the guise of problematic smartphone use.

Millennials and Gen Z

The current student populations that mainly comprise higher education are two cohorts, one known as Millennials (also often referred to as Gen Y or the Net Generation) and the other is labeled either Gen Z or the iGeneration (Gazzaley & Rosen, 2016). These two groups of students share many attributes, such as "computers, the Internet, mobile phones," and a "lifelong use of communication and technology" (Wiedmer, 2015, p. 54-55). The Millennial group has had much more focus on their generational tendencies than the upcoming Gen Z demographic, and one of the key characteristics linked to them is a general facility with – and enthusiasm for the use of – smartphones (Neumann, 2016; Wiedmer, 2015). As a result, several educators have attempted to incorporate elements of smartphone facilities (e.g., instructional support apps) into their presentations and learning approaches (Gerber & Ward, 2016). However, there seems to be a degree of blitheness on the part of some authors, such as Gerber and Ward (2016), as to the possibility of problematic smartphone use in a learning setting. On that note, several areas have been cited in which smartphones could have adverse issues (Neumann, 2016), including:

- difficulty with distinguishing valid sources of online information from specious origins
- shortened attention spans, derived from expectations of rapid access to sought-after material
- distractions from competing interests (e.g., text messages or social media notifications)

Thus, several concerns present themselves when smartphones are deployed, whether ostensibly for on-task purposes or surreptitiously with problematic activities (e.g., viewing entertainment media). The persistent use of personal digital devices for nonacademic functions could constitute a notable example of extraneous cognitive load (Choi et al., 2014; Moreno, 2006; Sweller, 2016), and also be indicative of a hyper attention cognitive mode (Hayles, 2007).

Smartphone Policies

The ubiquitous nature of smartphone ownership, along with their extensive capabilities (e.g., capturing photographs, telecommunications, and Internet access), has resulted in varied responses by educational institutions. The policies adopted by administrative levels and/or faculty members can range from full encouragement of use – as in a bring your own device (BYOD) stance – to partial or complete banning, typically because of smartphones' potential for cheating, mischief, or distraction (Berry & Westfall, 2015; Cheong et al, 2016; Flanigan & Kiewra, 2018; Gao et al., 2014; Mupinga, 2017). Although their study did not elucidate definitive reasons why school policies that restricted smartphone use were mostly unsuccessful, Gao et al. (2014) offered a few speculations, but did not reference the compulsive tendency associated with hyper attention use (Hayles, 2007). Another possibility (i.e., behavioral addiction tendencies with smartphones) is discussed more extensively below.

A further and later study supported the existence of a small dichotomy with perspectives on school policy strictness regarding smartphone presence in the classroom; this exploration displayed students as being more on the lenient side, while both teachers and parents leaned more toward the stringent side (Gao et al., 2017). However, the research result generated by this investigation did suggest that there was nominal agreement between the two major stakeholder groups (i.e., students versus parents and teachers) on limiting smartphone use during tests and other classroom activities (Gao et al., 2017).

Smartphone Addiction

The question regarding what constitutes a behavioral addiction is currently not well-established. There seems to be a growing consensus for including compulsive Internet use (particularly regarding social media access), which – due to the easy online path offered by smartphones – might implicate (at least by proxy) these mobile devices (Thombs & Osborn, 2019). However, what can be deemed as a behavioral addiction or not is still in dispute (Kardefelt-Winther et al., 2017). Continued investigation into this contentious arena may help resolve the issue in a more dispassionate manner (Kardefelt-Winther, 2014).

The territory involved with questions about whether or not addiction to mobile technology is a valid behavioral consideration is populated with advocates and a few skeptics, and appears to hold no easy answers (Gutiérrez et al., 2016). On the proponent side are concerns raised as to smartphone addiction and negative effects on academic performance (Hawi & Samaha, 2016), as well as a refinement with the addiction being to ever-present information access, as opposed to the smartphone itself (Kuss & Billieux, 2017). One of the perspectives held by the doubting contingent minimized the specter of addiction to no more than a compulsive tendency that can be managed in an educational setting (Loredo e Silva et al., 2018).

One of the first published studies relied on criteria for a similar behavioral addiction to television – based on items from the fourth edition of Diagnostic and Statistical Manual of Mental Disorders (DSM-4) – and adapted these to a scale for rating possible addiction to texting, which is known as short message system (SMS) activity (Perry & Lee, 2007). The results from this investigation, using self-reported responses by university students, implied that a small percentage of the respondents could be categorized as having addictive propensities for compulsive texting (Perry & Lee, 2007).

Although not targeting a student population, personality traits alleged to accompany addiction have also been used as criteria to see if these correlated with "problematic mobile phone use" (Takao et al., 2009, p. 4). Using these findings, areas of prediction for possible smartphone addiction included variables of gender, self-monitoring, and low approval motivation, but not loneliness (Takao et al., 2009). Another published account – involving adolescents generally, but not students explicitly – utilized a systematic review and meta-analysis approach, and discovered a selection of studies which collectively indicate a shockingly high percentage of smartphone addiction among the various populations (Davey & Davey, 2014). However, the validity of this research and its sources is questionable, due to the fairly small number of studies (a total of six) that comprised the systematic review, and also the wide-spread effect sizes (as measured by Cohen's d) with the variables that constituted the source investigations (Davey & Davey, 2014).

Addictive tendencies with smartphones after a year of iPhone use have been measured by self-reported responses from higher education students using a Smartphone Addiction Measurement Instrument (SAMI), a questionnaire that was patterned after the Cellular Phone Addiction Scale and Internet Addiction Test, which are similar surveys (Tossell et al., 2015). The results from this research found that over 50% of the participants exhibited some measure of smartphone addiction, although these findings are marred because of the small (n = 34) sample size (Tossell et al., 2015). A relatively recent literature review, although noteworthy for its elaboration on a number of validated instruments available for researchers' use with assessing the possibility of mobile phone addiction with study participants, is neither geared towards higher education students nor did any tables summarizing the outcomes from the selected sources find publication (Goswami & Singh, 2016). While these alone are not an indictment of the article, there tend to be some ready conclusion leaps exhibited by the authors, which sometimes border on alarmist tones.

A more recent and even-handed literature review approach, that included updated DSM-5 criteria related to substance use and compulsive gambling (as well as tabled data on prevalence statistics), still did not make a strong case for imputed smartphone addiction (Gutiérrez et al., 2016). Issues were noted conducting this type of research, which included discussion on methodological challenges, varying demographics, and psychological factors (Gutiérrez et al., 2016). While this multifold presentation of influences causes a number of difficulties with ascertaining demonstrable correlations, and the definitive answer as to whether mobile technology presents an addictive concern or not is not yet resolved, the problematic use of smartphones remains as an on-going issue (Gutiérrez et al., 2016).

Related Phenomena

Although not considered indicative of smartphone addiction per se, there are some adjunctive experiences reported by many owners of smartphones “stemming from misuse or overuse of technology, a condition commonly referred to as technopathology” (Deb, 2015, p. 231). A term now in use for owners who believe they hear their smartphone ringing (or feel it vibrating) is called “ringxiety,” which is also labeled phantom ringing or phantom vibration (Deb, 2015). Although much more research and information is needed with this novel phenomenon, it is possible to suggest that there may be a correlation between the experience and smartphone users who are overly involved with their devices (Deb, 2015; Rosen, 2012).

Effect on Learning

There are factors that might indicate significant tendencies toward over-reliance on smartphones, and whether this status could hold an influence on academic achievement (Lin & Chiang, 2017). Indications of smartphone dependency can best be predicted by a preference for using smartphones more for video entertainment and online games, as well as with users who perceive an easily-induced boredom (Lin & Chiang, 2017), both of which are in line with the hyper attentive mode proposed by Hayles (2007). The most relevant outcome suggested by the study was that “improper phone use can directly deteriorate students’ academic performance” (Lin & Chiang, 2017, p. 19).

Theoretical Considerations

Taking into account the possible impact on extraneous cognitive load by physical environmental influences in the classroom setting, compulsive and persistent engagement with problematic smartphone use by students (especially while otherwise participating in a structured learning activity) could conceivably be a detrimental factor on those students’ academic performance (Choi et al., 2014). The extenuated involvement by a student with his or her smartphone (regardless whether this is labeled a behavioral addiction or not) during educational presentations constitutes what is called an irrelevant distractor (Lavie et al., 2004), which can only compromise cognitive load levels on WM, with concomitant deleterious effects on LTM (Sweller, 2016). Perhaps the hyper attention cognitive mode outlined by Hayles (2007) is not necessarily an addiction per se, but it still can undermine academic achievement where deep attention mode is needed instead. If not diagnostically a behavioral addiction, there is some evidence of a compulsive tendency in place with problematic smartphone use. Whether this can then negatively impact the academic performance of university students is a further concern.

Multitasking

The term multitasking has both denotative and connotative sets of interpretation, in which the actual neurological meaning is “the concurrent processing of two or more tasks through a process of context switching,” while the implied general definition is the act of “performing two or more tasks simultaneously” (Ellis et al., 2010, p. 1). The corollary to the latter is one in which many individuals – particularly students – have the erroneous belief that the use of smartphones while conducting other activities allows them to be productive and efficient with their time (Ellis et al., 2010; Labăr & Ţepordei, 2019). However, when the human brain is presented with competing stimuli from multiple sources, attentional availability could be compromised and performance correspondingly impacted (Burgess et al., 2000; Chen & Yan, 2016; Gazzaley & Rosen, 2016).

Because of nuanced meaning, as well as an array of variant terms found in several fields of study for the phenomenon, attempts have been made to consolidate these disparate perspectives via a cross-discipline review (Lin et al., 2014). Besides comparing primary terminology, the authors’ main thrust was to investigate the research design associated with the

45 selected investigations to determine where these were effective or less so (Lin et al., 2014). The three principal drawbacks that were found included a limited agreement with study methodologies, a sparsity of instruments for measurement, and a lack of field-based research because the majority of investigations involved laboratory settings instead of a real-world environment (Lin et al., 2014).

A number of years after the article by Lin et al. (2014) appeared, a study was published that did incorporate real-time operations in a higher educational setting, and which targeted the influence of multitasking with smartphones on grade performance (Demirbilek & Talan, 2018). The authors utilized a control group (who were not allowed smartphone access) and two experimental groups (who did have different degrees of freedom to conduct smartphone functions) during lectures, and then compared the three groups' academic achievement with post-lecture test scores (Demirbilek & Talan, 2018). Because there were significant differences with academic performance between the control group and both of the experimental groups, Demirbilek and Talan (2018) hypothesized that the off-task activities using mobile technology negatively impacted cognitive function, which was evidenced by lower test scores with the experimental groups versus the control.

Effect on Academic Performance

To determine if the act of multitasking during instructional activities with smartphones has an effect on the academic achievement of higher education students, two groups in a classroom setting were compared (Ellis et al., 2010). After this experiment was conducted, the authors stated "(o)ur findings indicate that the exam scores of students who text in class are significantly lower than the exam scores of students who do not text in class" (Ellis et al., 2010, p. 1). Although the noted limitations (i.e., only one university setting was used and texting was the one multitasking factor) could plausibly be confounding, there is a sobering possible conclusion – which is directly related to extraneous distraction in the higher education classroom affecting academic achievement – to be derived from this particular study.

Adverse Outcomes

Although not directed toward a learning environment, the capacity of widely-varying participants to multitask was compared, and the conclusion suggested that dual-tasking tended to yield less-accurate results and more extended lengths of time to complete (Lin et al., 2016). By itself, this research might not have the same strength of evidence as the study by Ellis et al. (2010), but when brought in to play as another representation of possible deleterious effects from multitasking on mental capacity, it might seem that cognitive load theory is in action with this scenario (Lin et al., 2016).

Theoretical Considerations

Both working memory and cognitive load theories would likely underpin research efforts with multitasking considerations (Baddeley et al., 2010; Sweller, 2011). The tendency for mobile technology to induce additional cognitive tasking loads on working memory – due to activities such as texting or social media accessing concurrently while listening to an instructional presentation – would readily count as a source of irrelevant distraction (Lavie et al., 2004). Additionally, multitasking with personal digital devices during educational experiences in a classroom setting is a form of additional extraneous cognitive load generated within the physical learning environment (Choi et al., 2014; Moreno, 2006). One reason as to why many students attempt to multitask with smartphones in school might certainly be the predilection for hyper attention mode, characterized by perceived boredom and a need for high amounts of stimulation, which was posited by Hayles (2007) as a distinguishing trait with a newer generation of learners (Gazzaley & Rosen, 2016).

Smartphones and Academic Performance

Aside from the previous explorations into a possible addictive component with – and putative multitasking capacities of – smartphones (and with or without concerns as to effects on academic performance from either aspect), some studies have attempted to more directly look at what relationships might exist between problematic smartphone use (especially while in school) and grade achievement. One such effort (which did reference the concept of multitasking and also invoked both working memory and cognitive load theories) combined an investigative study into whether the nonacademic use of smartphones hampers working memory function, as well as the impact of classroom policies on smartphone presence in the classroom and academic achievement (Aaron & Lipton, 2018). The results gathered from this research appeared to show a notable correlation between the higher test scores and little to no use of smartphones by students, and also indicated a positive relationship between the more stringent classroom policies regarding mobile phone use and better academic performance (Aaron & Lipton, 2018).

Published close to the same time as the study by Aaron and Lipton (2018) was a meta-analysis that compiled 39 published investigations and compared these to ascertain possible overall effects, of which 36 displayed a negative relationship between smartphone use in educational settings and subsequent academic achievement (Kates et al., 2018). Despite a notable consistency with effect outcomes, the authors cautioned against establishing distinct causality, but did conclude that there is a strong suggestion of association between smartphone off-task use and grades (Kates et al., 2018). Thus, there was sufficient evidence to encourage future researchers to check the research design with the selected studies, and also state that "(w)hile it is not clear exactly why or how, there are just a handful of external factors that could be affecting the level of detriment or benefit of mobile phone detected by empirical studies" (Kates et al., 2018, p. 111).

Once more, working memory and cognitive load theories seem to be at the root of any potentially distractive elements attributed to the nonacademic engagement of smartphones by students and correspondingly diminished test scores (Baddeley, 2010; Sweller, 2011). The presence of this activity can readily be labeled a physical environmental source (Choi et al., 2014) of both irrelevant distraction and extraneous cognitive load, which have demonstrated adverse impacts on working memory limits and consequent information recall (Lavie et al., 2004; Moreno, 2006). Finally, there is a readiness with many current students to shift toward a hyper attentive mode (Hayles, 2007), which features:

- the tendency to need increased amounts of stimulation
- a desire for several feeds of sensation in a simultaneous manner
- the penchant to quickly switch thought paths among diverse objects of attention
- a susceptibility to easy restlessness with situations that do not feature the above qualities

Smartphones provide an all-too-easy opportunity for students with the inclination to function in a hyper attentive manner to fulfill most (or all) of the compulsions linked with this cognitive mode, but at the cost of potential distraction from structured learning and subsequent satisfactory achievement academically. If hyper attention is the outcome of a life-long engagement with other technological devices (e.g., computer games), then the presence of smartphones in the classroom becomes merely an extension of what has perhaps become more than a habitual inclination.

Use in Education

While acknowledging that problematic smartphone use in a classroom setting is a concern, with the main instigator for such being what the students perceive as a "less stimulating learning environment," behaviorism and constructivism have been invoked as the solutions (Barry et al., 2015, p. 207). Essentially, it seems that for smartphones – and, by extension, other devices (e.g., laptops) – to be used for educational purposes, the answer to offset potential decreases with academic performance lies with creating curriculum, lesson plans, and instructional approaches all designed to encourage creative use with smartphones in a learning context (Barry et al., 2015). While laudable, this has the appearance of appeasement (or capitulation) to a concern with problematic smartphone use also reported (based on survey responses by the study participants), which is students' awareness of the distractive nature of smartphones (and an associated possible negative impact on grade achievement), even while continuing to use their mobile phones for tasks unrelated to study or classroom presentation (Barry et al., 2015). Perhaps this is another indication as to the compulsive tendency to access their smartphones that many Millennial and Gen Z students have stated on various surveys (Hawi & Samaha, 2016).

Somewhat corroborating the challenge inherent with attempts to incorporate smartphone use as a learning tool, a meta-analysis approach to review this integration found that "very few studies have addressed how best to use mobile devices, and the effectiveness of doing so" (Sung et al., 2016, p. 253). In fact, this investigation unveiled varying results with what research has been executed toward ascertaining the value of smartphones (and their ilk), and – besides those subject domains (e.g., computer science) which lend themselves better to smartphone engagement – that there remains great uncertainty with long-term effectiveness and the development of higher-level abilities with mobile device use in the classroom (Sung et al., 2016).

One area of learning in which smartphones are being explored for use is with nurse training, and this involving a specific approach (i.e., simulation scenarios) to emulate real-life situations (Gambo et al., 2017). It was acknowledged that there can be hurdles with the implementation of a teaching strategy involving smartphones, including instructor buy-in and familiarity with the use of different mobile technologies, the cost and availability of equipment, and infrastructural reliabilities (Gambo et al. 2017). There were no stated concerns related to whether any distractive elements to learning with smartphones might present themselves, but it would appear that these would likely be negligible within an instructional event as highly-structured and tightly-regulated with deployment as this would seem to be. Still, it must be noted that the circumstances proposed would be exceptional within the broader realm of smartphone presence in classroom activities, and particularly so if problematic use was a possibility (Gambo et al., 2017).

Adverse Effects

One study that was conducted viewed the potential for reduced academic performance within the context of smartphone addiction levels, as well as referencing the effect of multitasking with mobile technology on cognitive load (Hawi & Samaha, 2016). Despite the contentiousness with whether a behavioral addiction to smartphone use is valid, there was a correlation found between those students who self-reported a strong risk of addictiveness with their smartphones and lower academic achievement (Hawi & Samaha, 2016). Furthermore, in addition to the correlation, the investigation did imply the possibility of causation (based on the strong odds ratio derived from the data) due to multitasking with smartphones while attending instructional presentations and subsequent impacts on grade performance.

A very recent investigation employed a comparison of the results obtained from responses to a smartphone use survey instrument – along with other variables derived from additional data collection – and a measure of academic achievement through scores achieved by students with their first exams (Baert et al., 2020). After conducting statistical analysis on the data gathered, the authors concluded that there was a strong correlational effect between student use of smartphones and academic performance, but also established the likely presence of a causal relationship as well. The replication of identical or similar studies to the one conducted by Baert et al. (2020) will be necessary to further corroborate the authors' findings.

One provocative experiment that involved not only the active use of smartphones (e.g., texting) as a factor for reduced cognitive performance, but also solely the proximity of one's mobile phone after it was turned off, thus without audible or visible distraction (Ward et al., 2017). The results indicated a negative effect on cognitive function by the presence of a powered-down smartphone. The premise supplied was that smartphone owners seem to have their attention diverted simply by mental considerations as to whether they are missing out on telecommunications, and this is sufficient distraction to lower cognitive abilities (Ward et al., 2017). While this study involved consumer participants, it is quite reasonable to extrapolate the concerning results toward an educational setting, and envision a correlation. Assuming repeatability of this research design within a scholastic learning context, one might witness a similar outcome, one in which Ward et al. (2017) reported:

> Our data indicate that the mere presence of one's smartphone adversely affects two domain-general measures of cognitive capacity – available working memory capacity (WMC) and functional fluid intelligence (Gf) – even when participants are not using their phones and do not report thinking about them. (p. 143)

It would appear that working memory and cognitive load theories are valid underpinning concepts for circumstances with mental distraction alone, and not necessarily always requiring some type of sensory stimuli (e.g., a smartphone notification tone or visible signal). If so, problematic smartphone use could also include simply having one's device close by.

Need for More Study

These varied investigations have offered some measure of insight into different perspectives regarding smartphones. Yet, should there be a demonstrable antipathetic academic outcome from problematic smartphone use (particularly during instructional activities), questions quickly emerge as to the role of educator-related stakeholders (i.e., administrators and faculty) regarding how best to address the phenomenon. School policies – especially if they ban or severely limit smartphone presence and engagement in a learning activity – ideally need to be based on empirical evidence. While studies have been conducted that provide at least some light on the issue, there is a pressing need for additional research to help elucidate the concern produced by problematic smartphone use and its impact on learning and academic performance in modern education.

Summary

Over the past 15 years or so, smartphones in the possession of students have become commonplace additions to the classroom and other locations on school premises. The presence of smartphones and their potential for either instructional support or distraction has been the focus of several educational studies and subsequent school policies. This is not without reason, because if problematic smartphone use – particularly in an off-task manner – does constitute an undesirable factor with increased cognitive load, then working memory is negatively impacted, along with the subsequent long-term memory storage of important learning material. Taking this theoretical premise further could indicate the strong probability of diminished academic performance, due to compromised long-term memory and an attendant reduction of information recall.

The current research literature is uncertain as to whether smartphone addiction is a real phenomenon or not, and also if multitasking with smartphones is detrimental to working memory limits. Suitable resolution of these factors could impact future considerations regarding changes with the development of school policies for the regulation of smartphone use by students. Ultimately, if a significant correlation can be shown to exist between problematic smartphone use (especially during instructional presentation) and a subsequent reduction of academic performance by students, there is certainly cause for concern.

However, the role of problematic smartphone use (most notably during classroom activities) as a possible contributor to increased cognitive load and its subsequent impact on working memory – hence negative effects on academic performance – has not been investigated to any substantial degree. There is thus a gap in the literature that warrants further exploration. Research into the interwoven considerations regarding problematic smartphone use and its potential for distraction with young adult students would further validate the idea of mobile phones as contributors to extraneous cognitive load, provide greater insight into what sort of administrative policies might need to be determined, and offer improved support for better instructional tactics with classroom management by teachers. The purpose of this research study was to add useful data and interpretive results into the maelstrom of problematic smartphone use and academic performance by university students.

CHAPTER THREE: METHODS

Overview

A correlational design was employed to discover if there is a statistically significant relationship between university students in a southwestern state who engage in problematic smartphone use and academic performance. Descriptions of the research design, research questions, null hypothesis, population, sample, groups, and setting are presented. The instrumentation for data collection was examined and then described in detail, as well as the development and rationale for its inclusion. Protocol steps that were incorporated with this research have been included to provide for similar studies. The appropriate data analysis is elaborated, including: analysis type, rationale, assumption tests, alpha levels, and the effect size.

Design

This quantitative correlational design explored the possible relationship between problematic smartphone use on the academic performance of university students. Correlational research design is an appropriate quantitative method because it can note possible behavioral pattern relationships between the variables that are studied. Further, it is a suitable method when two (or more) variables from one group are examined and each participant supplies information for two (or more) variables (Rovai et al., 2014). Finally, a quantitative correlational design is desirable and apt when an investigator would like to appraise a possible relationship between variables in a single group of participants. The results obtained from a correlational study may indicate the degree of a relationship with the variables, as well as whether a positive or negative direction appears to exist, all of which can be of great value in education (Gall et al., 2007).

Problematic smartphone use (PSU) is a term that describes behavior with a mobile device (especially during classroom activities), including texting, accessing social media, and viewing entertainment (Bolkan & Griffin, 2017; Chen & Yan, 2016; Wood et al., 2012), and constituted the independent variable with this study. The Smartphone Impact Scale (SIS) is a survey instrument that was utilized to obtain data on PSU with university students, and served as the measurement tool for the independent variable.

Academic performance is the scholastic achievement by students who are enrolled in a formal program of study, and constituted the dependent variable within this study. A student's averaged numerical grade is an officially collected and calculated metric that was utilized to obtain data on the academic performance of university students (individually and collectively), and served as the measurement tool for the dependent variable (York et al., 2015).

Specifically, the researcher was interested in discovering whether a relationship between PSU and academic performance may exist, as suggested by a correlation between the two variables. Because metrical analysis was required to ascertain the presence or absence of a correlation coefficient with PSU (as measured by survey data derived from the Smartphone Impact Scale- SIS) and academic performance (as measured by averaged numerical grades), a quantitative research method was the appropriate selection to help determine these answers (Creswell, 2008; Creswell & Creswell, 2018; Gall et al., 2007). As an approach type of quantitative research, correlational design is well-suited to demonstrate if one variable appears to influence another variable and – if so – by how much (Creswell, 2008). Furthermore, when the analysis of a correlational method displays a statistically significant relationship between the variables, this can indicate a possible important influence between the variables that are studied (Gall et al., 2007). Ultimately, the purpose for employing a quantitative research method – in the form of a correlational design – was to explore whether there is a significant relationship between PSU, as determined by SIS scores and the academic performance of university students, in the form of their averaged numerical grades.

Research Question

RQ1: Is there a significant relationship between problematic smartphone use, as measured by the Smartphone Impact Scale, and the academic performance of university students, as measured by their averaged numerical grades?

Null Hypothesis

$H_0$1: There is no significant relationship between problematic smartphone use, as measured by the Smartphone Impact Scale, and the academic performance of university students, as measured by their averaged numerical grades.

Participants and Setting

This investigation was conducted at a small private not-for-profit university located in a southwestern state during the winter trimester. The school is in a region with an estimated 7.4 million people inhabiting the densely populated urban and suburban municipalities (Hegar, 2018). Nearly half the region's population is White, with Hispanic and Black ethnicities comprising most of the remaining half (Hegar, 2018). The five noted household income levels are each close to the same average percentage, and major industries are related to oil and gas extraction, air transportation, and central banking functions (Hegar, 2018).

Population

The study population was drawn from a higher education institution with undergraduate and graduate programs that focus on healthcare topics ranging from clinician (e.g., diagnostic sonography) to business (e.g., health information). The school features students with a diversity of ethnic backgrounds (i.e., approximately 60% White, 7% African-American, 24% Hispanic, 4% Asian, 0% Pacific Islander, 2% American Indian, and 2% other), a narrow span of age groups (i.e., 83% between 19 and 30 years old), and an approximately even number of both genders (i.e., 41% male and 59% female). The university population is a homogenous representation of many higher education institutions.

Sample

The sample consisted of students from the population of students enrolled in different programs of study at the university. This institution of higher learning was chosen for this study due to the researcher being a faculty member with the school, and having strong collegial ties with many administrative and teaching staff. A convenience sample of students was drawn from the students enrolled in different trimester levels making up the College of Chiropractic doctoral degree program. The number of participants constituting the sample was 108 students, which exceeded the minimum requirement for a Pearson's *r* correlation coefficient of 66, assuming a medium effect size with statistical power of 0.7 and 0.5 alpha level (Gall et al., 2007). This number (i.e., 108 participants) allowed for the possibility of receiving any incomplete data that can occur during collection.

Participants

The participants making up the sample consisted of 108 university students, with 44 male and 64 female university students. The ethnicities of this group of students were White (n = 66), African-American (n = 8), Hispanic (n = 26), Asian (n = 4), Pacific Islanders (n = 0), American Indian (n = 2), and other (n = 2). The average age of the students that comprised the sample participants was 22 years of age. Table 1, 2, 3, and 4 respectively display the ethnic, gender, trimester level, and marital status demographics of the students in the sample when data collection was undertaken.

Table 1

Ethnic Demographics of the Sample

Ethnicity	*n*
White	66
African-American	8
Hispanic	26
Asian	4
Pacific Islander	0
American Indian	2
Other	2
Total	108

Table 2

Gender Demographics of the Sample

Gender	*n*
Male	44
Female	64
Total	108

Table 3

Trimester Level Demographics of the Sample

Trimester	*n*
Tri 1	35
Tri 2	53
Tri 3	8
Tri 4	12
Total	108

Table 4

Marital Status Demographics of the Sample

Status	*n*
Single	90
Married	17
Divorced	1
Total	108

The students in the sample were enrolled in various courses according to which trimester they were eligible to register for (see Appendix A for course titles). These courses range in topics from human sciences (e.g., anatomy, physiology, and pathology) to clinical skills (e.g., palpation), as per the standards established by the National Board of Chiropractic Examiners (NBCE). The curriculum aligns with NBCE stipulations, including learning objectives and textbook selections. Instructional methods used with classes feature lecture, media support, direct teaching, and hands-on demonstration with practicum. Students record notes and participate in exercises during class presentation. Homework includes slide show review, reports, and practice of hands-on activities.

Participants were derived from a convenience sample of university students enrolled in the Doctor of Chiropractic program (DCP). A request for study participation was emailed out to all DCP students during that trimester term (i.e., Winter 2022) who were then enrolled in one of the first four trimesters of the program. Necessary permissions were received from the Institutional Review Board (IRB) at Liberty University and the host school to conduct the investigation (see Appendix B for IRB approval). Informed consent was obtained from the students by means of an electronically signed document that disclosed (in plain language terms spoken by all the participants) the following:

- the participant's rights as a human subject for the investigative study
- the purpose of the investigative study
- the procedures to be undertaken with the investigative study (e.g., time length)
- the potential risks and benefits associated with participation in the investigative study
- the contact person(s) information for any questions or post-study concerns

The document also noted the voluntary nature of the study, the participant's right to confidentiality, that the participant's name would be de-identified, and the participant's right to withdraw at any time with no consequences (see Appendix D for the student consent form).

Instrumentation

The use of valid survey instruments for the measurement of variables is a necessary element in research (Creswell & Creswell, 2018). The data collection for the variables explored by this study consisted of the Smartphone Impact Scale (SIS) scores and students' averaged numerical grades. Data from scores obtained by participant completion of the SIS instrument constituted the independent variable, and sums derived from the participants' averaged numerical grades comprised the dependent variable.

Previous to the development of the Smartphone Impact Scale (SIS), most similar instruments had emphasized the possible addictive or other concerning aspects of smartphone activity. The behaviors attributed to problematic smartphone use (PSU) have included tendencies toward anxiety (when separated from one's smartphone), compulsive and repetitive checking for smartphone notifications, excessive smartphone activity, and distractedness while engaging with one's smartphone (Elhai et al., 2017). The SIS has consolidated a multitude of important and salient factors related to smartphone use into a suitable survey instrument for correlational research.

Smartphone Impact Scale

The Smartphone Impact Scale (SIS) – as developed by Pancani et al. (2019) – was administered, and the purpose of this instrument was to measure a range of constructs related to PSU by the participants. Constructs employed by the SIS have been suitably and properly defined, and are structured to examine seven dimensions of "cognitive, affective, social, and behavioral impacts" by smartphone use (Pancani et al., 2019, p. 2). The researcher obtained permission from the primary SIS instrument developer (i.e., Luca Pancani) to both use and publish the SIS items for the purpose of this study (see Appendix E for permission to use the SIS). The seven dimensions of smartphone use impact include self-perceived:

- loss of control of smartphone use
- nomophobia (i.e., the fear of being unable to access one's smartphone for interaction)
- smartphone-mediated communication
- emotion regulation through smartphone usage
- smartphone support to romantic relationships
- smartphone task supports
- awareness of smartphone negative impact

This instrument is an exceptionally recent development, and its use has only been documented in very few currently published research investigations. However, the validity of the measurement tool has been reinforced through the analysis of studies involving preliminary iterations of the SIS, (Pancani et al., 2019). In Study 1, the Smartphone Impact Scale-preliminary version (SIS-PV), the initial item pool was evaluated for dimensional reliability, and also explored for convergent validity with another already utilized instrument – the Smartphone Addiction Scale (Kwon et al., 2013) – to ascertain relative levels of internal consistency and correlation coefficients (Pancani et al., 2019).

Using outcomes derived from Study 1, including scale reduction and construct dimensionality analysis, a second exploration (i.e., Study 2) was undertaken (Pancani et al., 2019). Factor reliability was calculated for the seven items that eventually constituted the SIS, as determined by means of McDonald's (1999) omega, in order to supersede Cronbach's alpha constraints (Pancani et al., 2019). These factor reliability calculations are summarized below (Pancani et al., 2019):

- Loss of control of smartphone use = .91
- Nomophobia = .79
- Smartphone-mediated communication = .85
- Emotion regulation through smartphone usage = .92
- Smartphone support to romantic relationships = .84
- Smartphone task supports = .75
- Awareness of smartphone negative impact = .74

The definitions of each construct for the 26-item SIS, including the total number of subscale items, as stated by Pancani et al. (2019) are listed below:

- Loss of control of smartphone use was defined by these three items-
    - Others tell me I spend too much time on the smartphone
    - People around me often find my use of the smartphone excessive
    - Sometimes I have discussions with those around me about my excessive use of the smartphone
- Nomophobia was defined by these four items-
    - If my smartphone has a problem, it is the only thing I can think about
    - I'm terrified at the idea of losing my smartphone
    - If the smartphone turns off, I feel lost
    - I would panic if I realized I had forgotten the smartphone at home after going out to go to school/university/work
- Smartphone-mediated communication is defined by these four items-

    - I prefer to talk about my feelings via smartphone than face-to-face
    - I find it easier to keep virtual relationships than face-to-face relationships
    - I prefer to talk about my problems via smartphone than face-to-face
    - I prefer smartphone communications because you can decide if and when to intervene, unlike those face-to-face
- Emotion regulation through smartphone usage is defined by these four items-
    - When I'm angry, using smartphone makes me feel better
    - When I feel pressured, using the smartphone makes me feel better
    - If I'm sad, using the smartphone makes me feel better
    - When I'm nervous, using my smartphone makes me feel better
- Smartphone support to romantic relationships is defined by these three items-
    - The relationship with my partner would be affected by the absence of the smartphone
    - An important part of my relationship with my partner comes from smartphone communication
    - The smartphone helped me (or helps me) keep my relationship alive
- Smartphone task supports is defined by these four items-
    - The smartphone helps me remember what I have to do
    - My smartphone helps me perform tasks faster
    - Without my smartphone I would not be able to remember my appointments
    - The smartphone helps me in the day-to-day activities
- Awareness of smartphone negative impact is defined by these four items-
    - When I do not use the smartphone, I feel better

- I felt better when I had a normal mobile phone
- The smartphone is an overwhelming device
- When I do not use the smartphone, I feel more serene

The 26-item SIS had a six-point Likert-type scale that ranged from 1 = strongly agree to 6 = strongly disagree (Pancani et al., 2019). The combined possible score on the SIS has a range from 26 (i.e., the lowest score, indicating the perception of minimal negative impacts from smartphone use) to 156 (i.e., the highest score, indicating the perception of maximal negative impacts from smartphone use), thus providing the means to help quantify where on a spectrum PSU can be determined (Pancani et al., 2019).

The instrument took no more than 10 minutes for participants to complete, and the collected SIS questionnaires were then scored by the researcher. Permission to use the SIS instrument was requested by the researcher from the developer (Pancani et al., 2019), and then granted (see Appendix E for permission to use the SIS).

Academic Performance

The numerical grades of participants were obtained from the registrar's office at the university. These data were the most current available official listings for each participant, and were derived from the same trimester term (i.e., Winter 2022) when the participants completed the SIS survey instrument for this research. Academic performance was calculated by averaging the numerical grades for each course taken by each participant for the trimester term. The purpose of using averaged numerical grades was to objectively measure the most recent academic performance at the university by the participants (York et al., 2015).

Procedures

After receipt of written permission from the Liberty University Institutional Review

Board (IRB) and the host university (see Appendix B for approval) to conduct the investigation, data collection commenced at the beginning of the next trimester term (i.e., Winter 2022). An email was issued out by the researcher to all DCP students then enrolled in trimester one through four courses during the Winter 2022 term, soliciting their involvement with the investigation. This email noted that all participant names associated with the consent forms, and obtained by the survey responses, would be de-identified and made secure (see Appendix C for the study announcement and participation request script; see Appendix D for the student consent form). Two weeks before the deadline, the researcher issued out a reminder email to the target university student population, in order to obtain more responses to participate in the study.

A web-based platform (i.e., *REDCap*) was utilized by the researcher for the participants to – all through online means – complete the informed consent documents, supply demographic details, and respond to the Smartphone Impact Scale (SIS) survey. Participants were urged to completely and honestly respond to the questions that comprise the SIS by or before the stated deadline. The number of correctly completed SIS surveys that were returned to the researcher constitute the sample and consists of 108 total participants.

Once this SIS survey data, along with student identifying information for these participants, were collected by the researcher, the course numerical grades for each participant from the Winter 2022 term were also requested and subsequently obtained from the university registrar's office. All these data were linked between specific survey responses and corresponding averaged numerical grades, kept confidential, coded, and entered into SPSS for statistical analysis.

Data Analysis

A Pearson's *r* product-moment correlation coefficient analysis was performed to ascertain if a statistically significant relationship exists between the SIS survey responses and averaged numerical grades of the university students who participated in the study. The SIS instrument has been validated as a research variable (Pancani et al., 2019). The use of course numerical grades as a suitable variable is supported in the literature (York et al., 2015). The Pearson's *r* product-moment correlation coefficient is an appropriate selection to analyze the data for a correlational research design with two continuous variables because it explores whether a relationship exists between two variables, and its magnitude (Gall et al., 2007; Rovai et al., 2014).

Data screening was conducted to check for extreme outliers and inconsistencies (Green & Salkind, 2017). Collected data were examined for missing data points and the presence of extreme outliers by use of scatterplots. The scatterplot that was generated for this purpose did feature the appearance of one notable outlier. After removing this outlier from the original 108 total participants, a second scatterplot was produced from the revised collected data (n = 107), which did not display any extreme outliers. All assumption testing was then undertaken, using the revised dataset (n = 107) to ensure that the data met the assumptions of suitability for a Pearson's *r* product-moment correlation coefficient analysis.

Assumption testing of the investigative data (n = 107) was carried out by IBM SPSS Statistics version 28.0.1.0 (SPSS, Inc., Chicago, IL, USA). This assumption testing included an examination for the presence of extreme outliers, linearity, and bivariate normal distribution for each continuous variable: the impact of problematic smartphone use and academic performance. To test the assumptions of bivariate outliers, linearity, and bivariate normal distribution, one scatterplot was generated for all three assumption tests. An assumption of bivariate outliers test was conducted by using scatterplot analysis between the two variables – the SIS responses independent variable (x) and the academic performance dependent variable (y) – to verify that there is an absence of significant outliers with each variable (Rovai et al., 2014; Warner, 2013).

An assumption of linearity test was conducted by using scatterplot analysis between the two variables – the SIS responses independent variable (x) and the academic performance dependent variable (y) – to verify that there was a classic "cigar shape" of datapoint clustering (i.e., a symmetrical elliptical shape) with each variable, indicating a line of best fit, and thus confirming a linear relationship between the variables (Gall et al., 2007; Rovai et al., 2014; Warner, 2013). An assumption of bivariate normal distribution was conducted by using scatterplot analysis between the two variables – the SIS responses independent variable (x) and the academic performance dependent variable (y) – to verify that there was a classic "cigar shape" of datapoint clustering (i.e., a symmetrical elliptical shape) with each variable, indicating a normality of the two variables (Rovai et al., 2014; Warner, 2013).

The Pearson's *r* product-moment correlation coefficient analysis was performed at the 95% confidence interval level (alpha set at α =.05) to ascertain if there was a statistically significant relationship between the SIS response variable and academic performance variable scores. Pearson's *r* product-moment correlation coefficient was employed for interpretation of the effect size (Warner, 2013).

CHAPTER FOUR: FINDINGS

Overview

This quantitative correlational study was conducted to ascertain if a statistically significant relationship may be present between the problematic use of smartphones by students enrolled in a higher education institution and their academic performance. This chapter features the results of data collection obtained by means of the responses to a validated instrument supplied by a convenience sample of university students and their averaged numerical grades. Specifically, the contents of this chapter include the investigation's guiding research question, the null hypothesis, descriptive statistics for the study sample, and the inferential statistics derived from the statistical calculations.

Research Question

RQ1: Is there a significant relationship between problematic smartphone use, as measured by the Smartphone Impact Scale, and the academic performance of university students, as measured by their averaged numerical grades?

Null Hypothesis

$H_0$1: There is no significant relationship between problematic smartphone use, as measured by the Smartphone Impact Scale, and the academic performance of university students, as measured by their averaged numerical grades.

Descriptive Statistics

The data sources for this investigation were obtained from participant responses to the Smartphone Impact Scale (SIS), a validated and reliable survey instrument developed by Pancani et al. (2019) for measuring problematic smartphone use (PSU), and the participants' averaged numerical grades. The SIS was completed by in-residence graduate students at the participating higher education institution during the Winter 2022 term trimester by means of an online survey conducted via *REDCap*. From the 112 original participants, four did not elect to consent, which reduced the final number of participants to 108.

The score range for the SIS was from a low of 26 to a high of 156, with a higher score signifying a more problematic use of a smartphone. See Table 5 for a summary of the participants' lowest, highest, median, and mean SIS scores, along with 95% confidence intervals (CI) and the standard deviation (SD). See Table 6 for a summary of the participants' lowest, highest, and mean averaged numerical grades, along with the CI and SD.

Table 5

SIS Scores of the Sample

n	Lowest	Highest	Median	Mean	SD
108	63.0	139.0	102.0	102.6	16.8

CI [99.43, 105.85]

Table 6

Averaged Numerical Grades of the Sample

n	Lowest	Highest	Mean	SD
108	47.5	95.0	86.8	6.9

CI [85.48, 88.15]

Results

Hypothesis

$H_0$1: There is no significant relationship between problematic smartphone use, as measured by the Smartphone Impact Scale, and the academic performance of university students, as measured by their averaged numerical grades.

Data screening and statistical analyses were performed on both the independent variable (i.e., the SIS scores) and the dependent variable (i.e., the averaged numerical grades) using IBM

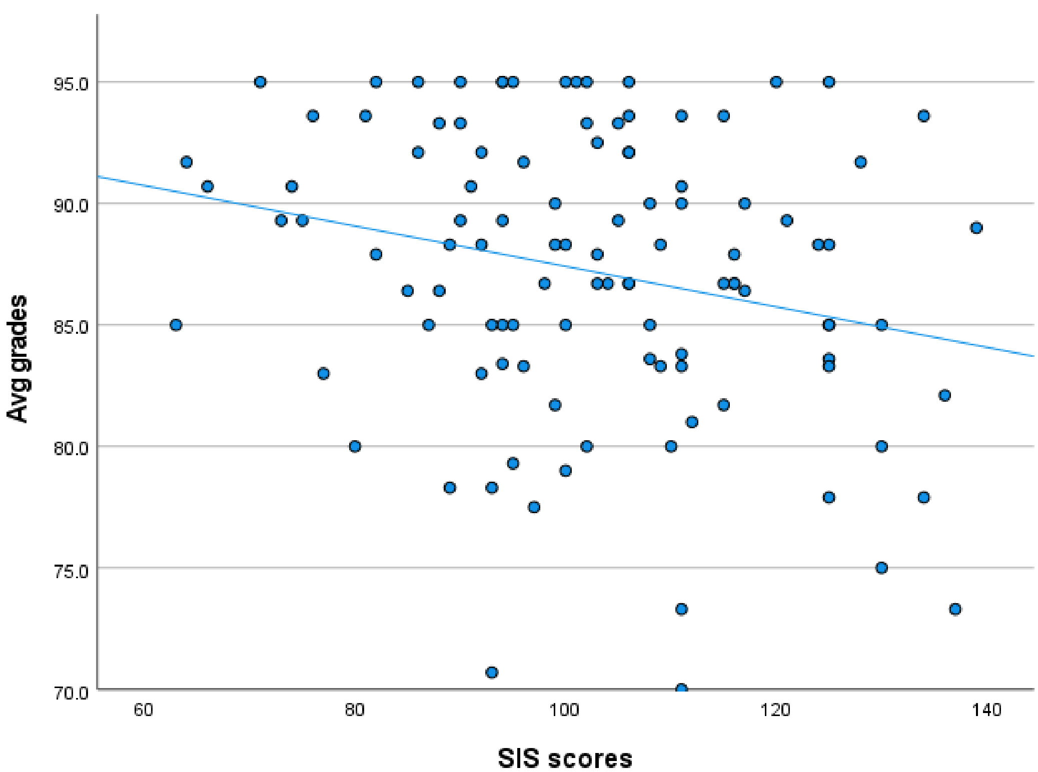
SPSS Statistics version 28.0.1.0 (SPSS, Inc., Chicago, IL, USA). This procedure included examination for extreme outliers, linearity, and bivariate normal distribution for each variable.

Assumption Tests

Scatterplot generation was conducted on the two variables and normality was displayed with both the independent (i.e., SIS scores) variable and dependent (i.e., averaged numerical grades) variable. This indicates that the assumption of bivariate normality is tenable. A scatterplot for both variables displayed linearity. See Figure 1 for a scatterplot depiction of the participants' Smartphone Impact Scale (SIS) scores (i.e., the independent variable on the x axis) the participants' averaged numerical grades (i.e., the dependent variable on the y axis).

Figure 1

Scatterplot of SIS Scores and Averaged Numerical Grades



Inferential Statistics

The null hypothesis with this investigation stated there is no significant relationship between problematic smartphone use (PSU), as measured by the Smartphone Impact Scale (SIS), and the academic performance of university students, as measured by their averaged numerical grades. The Pearson's *r* product-moment correlation coefficient analysis was performed at the 95% confidence interval (CI) level (alpha set at α =.05) to analyze the null hypothesis. Inferential statistical analysis was conducted using the revised dataset without the single outlier (*n* = 107).

The outcome of the inferential statistical analysis (*n* = 107) was significant where r(105) = -.239, *p* = .013), indicating that there was a negative correlation between the two variables (i.e., PSU and the academic performance of the participants), and denoting a medium effect size (Rovai et al., 2014; Warner, 2013). There is an approximate 24% variance with the dependent variable (i.e., academic performance) that can be attributed to the independent variable (i.e., problematic smartphone use). See Table 7 for a summary of results with the Pearson's *r* product-moment correlation coefficient analysis (*n* = 107). The null hypothesis was rejected.

Table 7

Pearson's r Product-Moment Correlation Coefficient Test

		SIS Totals	Averaged Grades
SIS Totals	Pearson's Correlation	1	-.239
	Sig. (2-tailed)		.013
	n	107	107
Averaged Grades	Pearson's Correlation	-.239*	
	Sig. (2-tailed)	.013	
	n	107	107

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

Summary

The details regarding data collection and statistical analysis procedures were outlined in this chapter. Collected data included the scores on the SIS instrument by the participants, as well as their averaged numerical grades for the same term. Statistical analysis was conducted to explore the possibility of a relationship between the independent variable (i.e., SIS scores) and the dependent variable (i.e., averaged numerical grades). In addition to descriptive statistics, the Pearson's *r* product-moment correlation coefficient analysis was applied to determine whether a relationship existed between the two variables.

The primary outcome derived from this investigation was that a negative correlation exists between the presence of problematic smartphone use (PSU) and academic performance. A medium effect size accompanied the Pearson's *r* product-moment correlation coefficient statistical analysis with the sample participants (n = 107). Based on the results of this study, there appears to be a statistically significant relationship between PSU (as measured by the SIS instrument) and academic performance (as determined by averaged numerical grades).

CHAPTER FIVE: CONCLUSIONS

Overview

This chapter examines the findings generated by the investigation as to the relationship between problematic smartphone use and the academic performance of university students. Discussion will focus on the guiding hypothesis, the results of this study, comparisons with recent literature on the topic, and the theoretical foundations. Both the implications for current-day higher institution-level education and the limitations present with this research study are addressed, along with recommendations for further investigative directions.

Discussion

This correlational design explored the question regarding whether or not a relationship exists between problematic smartphone use by university students in a graduate degree program and their academic performance. A validated survey instrument that measures problematic smartphone use (PSU) was taken by a convenience sample of university students, and the resulting scores were statistically analyzed – using a correlation coefficient – with the participant's averaged numerical grades. The guiding research question for this study, its results, recent related literature, and underpinning theories are discussed below.

Null Hypothesis

This research exploration was based on the following null hypothesis: "There is no significant relationship between problematic smartphone use, as measured by the Smartphone Impact Scale, and the academic performance of university students, as measured by their averaged numerical grades." This study found that there is a statistically significant correlation between increased problematic smartphone use (PSU) and reduced academic performance. These results are in line with findings by other researchers who have also investigated different elements of PSU in relation to aspects that constitute academic achievement (Aaron & Lipton, 2018; Baert et al., 2020; Hawi & Samaha, 2016; Kates et al., 2018; Sung et al., 2016). The findings generated by this correlational design research, along with other similar investigations, do not lend themselves to any causal attribution regarding the role of PSU and its impact on academic performance. Still, there is mounting associative evidence to more strongly support a 'what if' premise regarding the possible detrimental role played by PSU on academic achievement.

The prevailing theories driving concerns related to PSU and its potential effect on academic performance are those known as working memory (WM), developed by Baddeley and Hitch (1974), along with the cognitive load (CL) concept proposed by Sweller (1988). These combined theories, with their proposed operational capacity being compromised by attentional distractions, would appear vindicated by evidence that PSU appears capable of negatively affecting academic performance. In this particular circumstance, the working memory to long-term memory (LTM) process seems to suffer some degree of fragmentation of attention, which is further challenged by the presence of elevated cognitive loads. At the root of these compromises, both WM to LTM and increased cognitive loads, PSU is featured prominently as a likely contributor to lower academic achievement.

Implications

The findings generated by this correlational investigation have contributed another item of weight to the concerns expressed by previous researchers as to a potentially undesirable influence by problematic smartphone use (PSU) on the academic performance by students (Aaron & Lipton, 2018; Kates et al., 2018). When taken into account with the extant literature on the impact of PSU possibly affecting requisite learning elements necessary to achieve academic success (e.g., short-term to long-term memory ability, cognitive load management, and attentional capacities), this study has added another layer of suspicion as to the apprehension that smartphone distractions could reduce information processing sufficiently to impact students' grades (Baddeley & Hitch, 1974; Schunk, 2016; Sweller, 1988). The confirmatory outcome with this research helps bring more circumstantial evidence to the still-open arena within the current published investigations regarding the extent to which PSU may interfere with the cognitive learning abilities of students, thus resulting in detrimental effects on their academic achievements (Aaron & Lipton, 2018; Baert et al., 2020; Hawi & Samaha, 2016; Kates et al., 2018; Sung et al., 2016).

If, as is suggested by this and prior research discoveries, there is not only a strong correlational connection between PSU and academic performance but also possibly a causal link, the ramifications are troubling. Should an indisputable relationship be demonstrated showing an adverse effect on academic achievement produced by PSU, considerations as to policies with smartphone presence or usage in a classroom setting would need reevaluation. Further, if any smartphone policies subsequently adopted were draconian, could buy-in with enrolled students be established? At the other end, should leniency with smartphone policies be put into place, should disclosure be rendered as to the possibility of unfavorable influences on students' grades by PSU? The implied negative outcomes beg these and other questions.

Limitations

Within the context of this investigation's design and setting, some limiting considerations are in place. Internal validity may be threatened due to this study being the first to use English translations of the Smartphone Impact Scale (SIS), which was originally developed and tested using Italian language compositions of the survey's dimensions (Pancani et al., 2019). Because the SIS instrument represents the measurement tool for the independent variable, any deficits with its capacity for such has the possibility of affecting its correlation to the dependent variable (i.e., averaged course grades). However, with correlational research that involves an independent variable utilizing language nuance as its metric, there is always a slight compromise likely with internal validity. Another aspect of internal validity limitation is the convenience sample nature with the participant selection, which decreases the randomization factor.

Arguably the primary threat with the external validity of this research study is the population sample and the manner in which it was determined. The students who acted as participants were intentionally drawn from the first four terms of a doctoral degree program at a university in Texas where the researcher is an adjunct instructor, teaching an elective course in the program. Because the researcher only has students enrolled in the fifth, sixth, or seventh term, none of the students who were participants during the SIS survey data collection time-frame were also concurrently taking the researcher's elective course, thereby eliminating any bias with either party. Despite this, being students enrolled in a healthcare practitioner doctoral degree program is not representative of other university student populations (e.g., other graduate or undergraduate degree levels and professional directions), thus the study results may not generalize to other programs in institutions of higher learning.

Finally, the nature of a correlational study such as this will affect its overall validity due to the findings being inferential only and non-conclusive. Despite obtaining a statistically significant result with this investigation from the Pearson's *r* product-moment correlation coefficient analysis, definitive cause-and-effect cannot be construed for the two variables. Although a relationship has been shown by this research study to exist between problematic smartphone use and academic performance, there could be one or more unknown confounding variables in play that might have influenced the findings. Because a correlational research design lacks the element of independent variable manipulation, as would constitute an experimental design approach, a causality between the variables cannot be posited.

Recommendations for Further Research

Both the independent variable – problematic smartphone use (PSU) and its measurement by the Smartphone Impact Scale (SIS) – and dependent variable (i.e., averaged course grades) used in this investigation would lend themselves as suitable elements for similarly formatted correlational studies conducted at other university settings and in different geographical locations. Doing so would provide additional data towards a better consensus as to the possible deleterious effects of PSU on academic achievement with other population samples (e.g., undergraduate students). The diversity of results obtained would assist with better generalization of findings to a wider array of student populations that are enrolled in various programs at institutions of higher education.

An experimental design, featuring a randomized controlled trial (RCT) conducted in a university setting, would be the ideal manner in which to explore PSU as a possible causal factor on academic achievement. A model for this could be built upon the research design invoked by Ward et al. (2017), but using students as participants instead of consumers, and involving more of a scholastic formulation with the testing. A series of similarly constructed investigations using RCTs, conducted at a number of geographical locations and incorporating different program degree levels, would produce interesting comparative findings.

Lastly, another possible research direction to follow would be one using a mixed-methods design. The incorporation of a qualitative component within a quantitative construct could add a robust set of insights into the mindset of the participants, yielding useful data with student perspectives on both the positive and negative capacities of smartphones within a scholastic environment. In this way, more light could be shed on student motivations and reactions with their use of smartphones, and whether there is any cognizance as to the possible benefits or harms associated with these ubiquitous devices.

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APPENDICES

Appendix A: Course Titles for Each Trimester

Trimester 1 Courses-

- Biology of Cells and Tissues
- Development and Applied Anatomy
- Biochemistry I
- Foundations of Chiropractic
- Introduction to Clinical Reasoning
- Clinical Psychology
- Fundamentals of Diagnostic Imaging

Trimester 2 Courses-

- Gross Anatomy I
- Physiology I
- Microbiology/Immunology
- Biochemistry II
- Clinical Biomechanics/Motion Palpation
- Chiropractic Methods I
- Clinical Imaging I

Trimester 3 Courses-

- Gross Anatomy II
- Physiology II
- Public Health
- General Pathology
- Chiropractic Principles/Philosophy
- Analysis & Adjusting Technique I
- Extra Spinal Analysis & Tech. Upper Extremity
- Clinical Imaging II

Trimester 4 Courses-

- Neuroscience
- Systems Pathology
- Analysis & Adjusting Technique II
- Extra Spinal Analysis & Tech. Lower Extremity
- Physical Diagnosis
- Clinical Imaging III
- Clinical Nutrition

Appendix B: Institutional Review Board Permission

An email of permission to conduct the dissertation research was received January 26, 2022, from the Liberty University Institutional Review Board, and is reproduced below:

Re: IRB Exemption - IRB-FY21-22-35 The Relationship Between Problematic Smartphone Use and the Academic Performance of University Students

Dear Richard Robinette, Rebecca Lunde,

The Liberty University Institutional Review Board (IRB) has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study to be exempt from further IRB review.

This means you may begin your research with the data safeguarding methods mentioned in your approved application, and no further IRB oversight is required.

Your study falls under the following exemption category, which identifies specific situations in which human participants research is exempt from the policy set forth in 45 CFR 46:104(d):

Category 2.(iii). Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met:

The information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by §46.111(a)(7).

Your stamped consent form(s) and final versions of your study documents can be found under the Attachments tab within the Submission Details section of your study on Cayuse IRB.

Your stamped consent form(s) should be copied and used to gain the consent of your research participants.

If you plan to provide your consent information electronically, the contents of the attached consent document(s) should be made available without alteration.

Please note that this exemption only applies to your current research application, and any modifications to your protocol must be reported to the Liberty University IRB for verification of continued exemption status.

You may report these changes by completing a modification submission through your Cayuse IRB account.

If you have any questions about this exemption or need assistance in determining whether possible modifications to your protocol would change your exemption status, please email us at irb@liberty.edu.

Sincerely,

G. Michele Baker, MA, CIP
Administrative Chair of Institutional Research
Research Ethics Office

Appendix C: Study Announcement

Dear potential research participant:

As a graduate student in the School of Education at Liberty University, I am conducting research as part of the requirements for a Doctor of Philosophy (PhD) degree. The purpose of my research is to see if there is a significant relationship between problematic smartphone use and the academic performance of university students, and I am writing to invite eligible participants to join my study.

Participants must be 18 years of age (or older) and currently enrolled as a full-time student in the Parker University Doctor of Chiropractic Program, taking courses in one of the first four (4) trimesters, and currently owning and using a smartphone.

Participants, if willing, will be asked to take a short survey and sign a FERPA Authorization form so that I may access their grades for data analysis. It should take approximately 10 minutes to finish the entire process. Names and other identifying information will be requested as part of this study, but the information will remain confidential.

To participate, please click here *(hyperlink to online consent form and survey)* to complete the online survey.

A consent document is provided as the first page of the survey. The consent document contains additional information about my research.

If you choose to participate, after you have read the consent form, please sign it by typing your name and the date and proceed to the survey. Please also sign the FERPA Authorization form granting me access to your grades.

Participants will be entered in a raffle to receive a $100 Amazon gift card.

Sincerely,

Richard Robinette

Appendix D: Participant Consent Form

Title of the Project: Smartphone Use and Academic Performance
Principal Investigator: Richard Robinette, MBA (Liberty University)

Invitation to be Part of a Research Study

You are invited to participate in a research study. To participate, you must be 18 years of age (or older) and currently enrolled as a full-time student in the Parker University Doctor of Chiropractic Program. Taking part in this research project is voluntary.

Please take time to read this entire form and ask questions before deciding whether to take part in this research.

What is the study about and why is it being done?

The purpose of the study is to see if there is a significant relationship between problematic smartphone use and the academic performance of university students. It is designed to quickly obtain a participant's response regarding his or her interaction with a personal smartphone, and then compare these responses to that participant's academic performance.

What will happen if you take part in this study?

If you agree to be in this study, I will ask you to do the following:

1. Complete the survey and demographic questions as honestly as possible (this should take approximately 10 minutes to finish).

How could you or others benefit from this study?

Participants should not expect to receive a direct benefit from taking part in this study.

Benefits to society include a greater understanding as to whether or not smartphone use by full-time students in a graduate degree program impacts academic performance.

What risks might you experience from being in this study?

The risks involved in this study are minimal, which means they are equal to the risks you would encounter in everyday life.

How will personal information be protected?

The records of this study will be kept private. Published reports will not include any information that will make it possible to identify a subject. Research records will be stored securely, and only the researcher will have access to the records.

- Participant responses will be kept confidential through the use of codes.
- Data will be stored on a password-locked computer and may be used in future presentations. After three years, all electronic records will be deleted.

How will you be compensated for being part of the study?

Participants will not be compensated for participating in this study. However, all participants who satisfactorily complete the survey (i.e., respond to each and every item) will be entered in a raffle to receive a $100 Amazon gift card.

Does the researcher have any conflicts of interest?

The researcher serves as an adjunct instructor at the Parker University College of Chiropractic. To limit potential or perceived conflicts, the study will be anonymous, so the researcher will not know who participated. This disclosure is made so that you can decide if this relationship will affect your willingness to participate in this study. No action will be taken against an individual based on his or her decision to participate or not participate in this study.

Is study participation voluntary?

Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with Parker University. If you decide to participate, you are free to not answer any question or withdraw at any time prior to submitting the survey without affecting those relationships.

What should you do if you decide to withdraw from the study?

If you choose to withdraw from the study, please exit the survey and close your internet browser. Your responses will not be recorded or included in the study.

Whom do you contact if you have questions or concerns about the study?

The researcher conducting this study is Richard Robinette. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact him at [redacted]. You may also contact the researcher's faculty sponsor, Dr. Rebecca M. Lunde, at [redacted].

Whom do you contact if you have questions about your rights as a research participant?

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the Institutional Review Board, 1971 University Blvd., Green Hall Ste. 2845, Lynchburg, VA 24515 or email at irb@liberty.edu.

Disclaimer: The Institutional Review Board (IRB) is tasked with ensuring that human subjects research will be conducted in an ethical manner as defined and required by federal regulations. The topics covered and viewpoints expressed or alluded to by student and faculty researchers are those of the researchers and do not necessarily reflect the official policies or positions of Liberty University.

Your Consent

Before agreeing to be part of the research, please be sure that you understand what the study is about. You can print a copy of the document for your records. If you have any questions about the study later, you can contact the researcher using the information provided above.

I have read and understood the above information. I have asked questions and have received answers. I consent to participate in the study.

Appendix E: Smartphone Impact Scale Survey Developer Permission

The following email was sent on April 27, 2020, to Dr. Luca Pancani requesting permission to use the Smartphone Impact Scale (SIS), which Dr. Pancani and associates developed as a survey instrument to measure problematic smartphone use (PSU).

Request for permission to use the Smartphone Impact Scale (SIS)

April 27, 2020
2.43pm

Robinette, Richard [redacted]

To: [redacted]
Cc: [redacted]

Dear Dr. Pancani...

I am a doctoral candidate enrolled in a PhD program with the School of Education (SOE) at Liberty University. As part of my research for the literature review section with my dissertation, I discovered the article you and your co-authors wrote -- The Psychology of Smartphone: The Development of the Smartphone Impact Scale (SIS) -- which reported on the development of the SIS and its potential applications. I was very impressed with the amount of effort that was expended to formulate and validate the SIS components, as well as the comprehensive nature of the instrument.

The English version of the SIS instrument that you developed would be a critical measurement tool for the quantitative correlational research design I plan to employ for my dissertation, which is focused on the possible relationship between problematic smartphone use (PSU) and the academic performance of university students. To that end, I would like to formally request permission to use the English translation of the SIS for this purpose. Please advise me as to what protocol (if any) might be needed to obtain full and complete permission from you for the employment of the SIS tool (English version) as a data collection instrument for my dissertation.

I have copied my dissertation committee chair (Dr. Rebecca Lunde) on this communication. If you would be so kind, please include her with any email response.

Thank you so very much. I greatly appreciate your assistance with this important request, and I look forward to taking the next step.

Sincerely...

Richard Robinette, MBA
L30294399

The email reply from Dr. Pancani is below:

Re: Request for permission to use the Smartphone Impact Scale (SIS)

April 28, 2020
2:22am

Luca Pancani [redacted]

To: [redacted]
Cc: [redacted]

Dear Richard,

Thank you very much for the compliments. I'm happy you appreciated the paper and you would like to use our scale in your research.

There are no specific permission to use it, just employ the items and the response scale as it is.

If you will be so kind, I would like to be briefly informed about your results, once you will have completed your study(ies). Currently, there are some research groups around the world that are translating and validating the SIS in different languages and I'm always interested in knowing how the SIS performs. Thus, If you publish a paper in which you employed it, please let me know.

If you need and further advice, you can email me whenever you want.

Good luck for your research!

Best wishes,
Luca