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The effects of mobile phone use on academic performance: A meta-analysis

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ABSTRACT

Purpose: Although the mobile phone has been conspicuously proliferated in the past decades, little is known about its influence; especially its effect on student learning and academic performance. Although there is a growing interest in mobile devices and their correlates and consequences for children, effects vary across related studies and the magnitude of the overall effect remains unclear. The purpose of this study is to further examine any relationships that may exist between mobile phone use and educational achievement.

Research design: A meta-analysis of research conducted on the relationship between mobile phone use and student educational outcomes over a 10-year period (2008–2017) was conducted. The operational definition of cell phone use to guide the implementation of this study is: any measure of mobile phone use, whether considered normative or problematic, that quantifies the extent to which a person uses a phone, feels an emotional or other dependence on a phone, or categorizes the types of uses and situations in which use occurs. Studies examining use for the express purpose of educational improvement are not included, as the aim of this study is to ascertain the effects of normal smartphone use. The operational definition of academic achievement to guide the implementation of this study is: any measure that quantifies the extent to which a student or group of students is performing or feels he or she is performing to a satisfactory level, including but not limited to letter grades and test scores, knowledge and skill acquisition, and self-reported measures of academic ability or difficulty.

Findings: The overall meta-analysis indicated that the average effect of mobile phone usage on student outcomes was $r = -0.162$ with a 95% confident interval of -0.196 to -0.128. The effect sizes of moderator variables (education level, region, study type, and whether the effect size was derived from a Beta coefficient, and mobile phone use construct) were analyzed. The results of this study and their implications for both research and practice are discussed.

In September of 2017, the Atlantic posed a jarring question: “Have smartphones ruined a generation?” (Twenge, 2017). That article, as well as recent research, details alarming trends of depression, isolation, and suicide that have increased since the proliferation of smartphones (Kim, Cho, & Kim, 2017; Wang et al., 2014). Effects of technology on mental health, education, and other important human spheres are not new. Evidence of similar fears about the digital revolution were present in the 1990s, well before the advent of smartphones. Sawyer's (1999) assessment of people's then-current online information use habits, for instance, suggested a “… declining ability to think critically, spell[ing] trouble ahead” (p. 1). Sustained and systematic examination of empirical evidence is necessary for arriving at rational, rather than fearful, conclusions regarding the effects of emerging technology on individuals and

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society.

1. Literature review

There is a growing interest in exploring the effects of mobile phone use on academic achievement. In contrast to the plethora of research on the effects of internet use, far less is known about general mobile phone and consequences for children (Jackson, Von Eye, Fitzgerald, Witt, & Zhao, 2011).

Of the empirical investigations that have been conducted on the effects of mobile phone use, the observed effects are not homogeneous in either size or direction, ranging from positive and negative to zero effect (Chen & Yan, 2016; Rashid & Asghar, 2016). Most studies, however, support the proposition that a negative relationship does exist between smartphone dependency and student academic performance (Aman et al., 2015; Elder, 2013; Gupta, Garg, & Arora, 2016; Kuznekoff & Titsworth, 2013; Lepp, Barkley, & Karpinski, 2015; Li, Lepp, & Barkley, 2015; Lin & Chiang, 2017; Longnecker, 2017; Rashid & Asghar, 2016; Samaha & Hawi, 2016). Hawi and Samaha (2016) surveyed 293 university students and noted "… the unlikeliness of students at high risk of smartphone addiction achieving distinctive academic performance" (p. 87). Likewise, in a study of 210 university students in Seoul, South Korea, Lee, Cho, Kim, and Noh (2015) confirmed that the more severe a student's mobile phone addiction, the lower the student's levels of self-regulated learning and flow when studying, thus decreasing student achievement. Similar results were also found among K-12 school students (Akgül, 2016; Gi, Park, Kyung, & Park, 2016). Based on a national sample of 2159 middle and high school students, Gi et al. (2016) found that smartphone dependency negatively predicted both students' language arts and mathematics achievement. From another perspective, Beland and Murphy (2016) investigated the impact of schools banning mobile phones on student test scores and found that "… banning mobile phones improves outcomes for the low-achieving students the most (14.23% of a standard deviation) and has no significant impact on high achievers" (p. 70).

Other studies, however, have found no adverse effects of mobile phone use on academic achievement (Ishii, 2011). Dos (2014) suggested a negative relationship does not exist since people have become accustomed to living with mobile phones. These divergent results may be due to the different purposes of mobile phone use. Drawing from a sample of 348 undergraduate students in Hong Kong, Lau's study (2017) shows a non-significant relationship between mobile phone use for academic purposes and student achievement, while a statistically significant negative relationship was found between mobile phone use for non-academic purposes and academic outcomes. Similar results have been found by Akgül (2016) and Jackson et al. (2011). Chen and Yan (2016) reviewed the effects of smartphone use on learning in terms of three aspects: (1) the ways mobile phones impair learning, (2) the reasons for impairment of mobile phones on learning, and (3) methods to prevent mobile phone distractions. However, different results are often found when examining the effects of using mobile phones as a teaching tool. In a meta-analysis, Sung, Chang, and Liu (2016) indicated a moderate positive effect of 0.523 for the application of mobile devices to education.

No clear consensus regarding the size and direction of the effects of mobile phone use on academic performance exists within the scholarly literature. While most studies suggest a negative relationship, there is, nonetheless, a wide range of effect sizes. This ambiguity in the research literature suggests a need for estimating the true summary effect of mobile phone use on academic performance.

2. Purpose statement & research questions

The purpose of this study is to explore any relationships that may exist between mobile phone use and educational achievement. There are several important factors necessitating this study: (1) mobile phones are increasingly ubiquitous across all age groups and school levels; (2) while mobile phones can be useful tools, negative findings about their effects on mental health suggest that researchers should investigate how they could be affecting other areas of life; and (3) as educational outcomes are directly indicative of later-life economic and health outcomes, examining any potential relationship is crucial.

To investigate any relationships that may exist between mobile phone use and educational achievement, the following research questions were posited:

1. What relationships exist, if any, between mobile phone use and educational achievement?
2. What, if any, factors moderate the relationship between mobile phone use and educational achievement?

3. Methods

3.1. Inclusion and exclusion criteria

Studies were eligible for inclusion in the meta-analysis if they conformed with the following three criteria:

1. Studies of the relationship between cell phone usage for non-educational purposes and student academic achievement. The article measured some sort of construct of mobile phone use such as: (a) number of text messages or phone calls sent/received in a given period, (b) measure of mobile phone addiction, or (c) time spent using a mobile phone for various purposes in a given period. If the principal measure was computer or internet use then the study was excluded.
2. Student learning achievement was presented as a major dependent variable measured by some construct of academic achievement such as: (a) GPA, (b) raw test scores, (c) overall class scores, (d) self-report of academic achievement, and (e) performance on any

researcher-constructed learning tasks and tests, difficulty, etc. Studies for which the results were related to affective variables (e.g., learning attitude or learning motivation) but without learning outcome were excluded.

3. Sufficient and appropriate data was presented to calculate effect sizes, such as means, standard deviations, t, F, or χ^2 values, or the number of people in each group. Articles in which the sample sizes of each group were not noted, lacked any inferential statistical results, or had inferential statistical results but were still inadequate for calculating an effect size were excluded.

3.2. Search strategies

Multiple approaches were employed to identify relevant studies. A targeted search of the research literature in Google Scholar was conducted, supplemented with the Western Michigan University Library database search tools. A particular search term was used to identify the viable literature. Boolean operators were employed to create the following search syntax:

allintitle: "cell phone" OR ″smartphone" OR ″smart phone" OR ″mobile phone" AND ″academic performance" OR ″academic achievement" OR ″academic outcomes" OR ″educational achievement" OR ″educational performance".

In addition, the reference lists of included studies were reviewed for relevant studies that were not located through the electronic search.

3.3. Coding procedures

The initial search identified 117 studies. Two authors independently screened potential relevant sources, which resulted in the selection of 39 studies. For the independent screening procedure, observed agreement was $p_o = 0.84$ and agreement accounting for chance was $\kappa = 0.66$.

After screening, each study was reviewed to identify key characteristics. Descriptive characteristics (e.g., sample sizes, grade level, year) as well as statistical data were extracted from each study and entered into the Qualtrics online survey platform based on a coding schema. All articles were double-coded to determine inter-rater reliability. For the article coding procedure, observed agreement was $p_o = 0.83$ and agreement accounting for chance was $\kappa = 0.48$.

3.4. Moderator and mediator analysis

Several characteristics of each sample were coded as potential moderators: (a) grade level (K-12 or college), (b) research design (survey or experiment), (c) year of study, (d) region or country in which the study was conducted (Mid-Eastern, Asia, the United States, and Other), (e) whether the effect size was presented in the form of a β coefficient or not in the study, and (f) mobile phone use construct.

3.5. Data processing and analysis

Pearson correlation is an intuitive way to reflect the effects of mobile phone use on student academic outcomes. Thus, for each independent study, r was extracted or computed using the information available in the study. However, the summary effect size was not performed on the correlation coefficient itself. Instead, the coefficient was transformed to the Fisher's z scale, and all analyses were performed using the transformed values. Finally, the Fisher's z value was converted back to a correlation coefficient (Borenstein et al., 2009). Comprehensive Meta-Analysis software was used to compile the effect size data and conduct analyses.

4. Results

4.1. Overall effect

The 39 studies included (40 effect sizes) in the analysis consist of 148,883 students covering K-12 (135,131 students) and college (13,752 students) from 14 countries and regions (i.e., United States, Turkey, Middle East, Taiwan, India, Brazil). The forest plot of effect sizes and the 95% confidence interval of the 39 studies are shown in Fig. 1. As shown in the figure, the effect sizes range from −0.49 to 0.09. Thirty-six (36) of the studies reported a negative relationship and 3 reported a positive relationship. Under the random effects model, the summary estimate of the correlation between mobile phone usage and student academic achievement is −0.16 with a 95% confident interval of −0.20 to −0.13. The Z-value is −9.14, $p < .001$, indicating 2.62% of the variance shared between the two variables is statistically significant. Using the fixed-effect weights, the summary estimation of $r = -0.07$ with a 95% confidence interval having a lower limit of −0.07 and an upper limit of −0.06.

4.2. Test for heterogeneity

Heterogeneity in effect sizes was tested under the null hypothesis that all of the studies share a common true effect size. Results indicated the studies were heterogeneous ($Q = 335.4$, $df = 39$, $p < 0.001$), providing evidence that the true effects were not consistent from one study to the next. Under the fixed-effect model, the I^2 statistic indicated that 88.34% of the observed variance reflects real differences in effect size. The value of $\tau^2 = 0.01$ and $\tau = 0.09$. Using these values a 95% prediction interval with a lower limit of

Model	Study Name	Grade Level	Design	Statistics for Each Study				
	Elder, 2013	College Undergrad	Experiment	-0.49	-0.69	-0.22	-3.31	0.00
	Pierce et al., 2008	K-12	Survey	-0.45	-0.62	-0.25	-4.04	0.00
	Gingerich et al., 2014	College Undergrad	Experiment	-0.46	-0.59	-0.22	-3.90	0.00
	Dietz et al., 2014	College Undergrad	Experiment	-0.42	-0.56	-0.26	-4.70	0.00
	McDonald, 2013	College Undergrad	Survey	-0.41	-0.55	-0.25	-4.69	0.00
	Froese et al., 2012	College Undergrad	Experiment	-0.39	-0.52	-0.24	-4.84	0.00
	End et al., 2010	Eollege Undergrad	Experiment	-0.35	-0.54	-0.12	-2.98	0.00
	Kuznekoff et al., 2013	College Undergrad	Survey	-0.33	-0.55	-0.06	-2.38	0.02
	Felosini, 2017	College Undergrad	Survey	-0.30	-0.55	0.00	-1.97	0.05
	Hong et al., 2012	College Undergrad	Survey	-0.30	-0.41	-0.19	-5.07	0.00
	Gingerich et al., 2014 (2)	College Undergrad	Experiment	-0.27	-0.49	-0.02	-2.11	0.04
	Longnecker, 2017	College Undergrad	Survey	-0.25	-0.39	-0.10	-3.23	0.00
	Peiro-Velert et al., 2014	College Undergrad	Survey	-0.25	-0.28	-0.22	-14.2	0.00
	Lepp et al., 2015	College Undergrad	Survey	-0.23	-0.31	-0.15	-5.41	0.00
	Sanchez-Martinez et al., 2009	K-12	Survey	-0.22	-0.29	-0.13	-5.14	0.00
	Olufadi, 2015	College Undergrad	Survey	-0.21	-0.32	-0.10	-3.64	0.00
	Tossell et al., 2015	College Undergrad	Experiment	-0.21	-0.39	-0.01	-2.01	0.05
	Hawi, 2016	College Undergrad	Survey	-0.20	-0.32	-0.08	-3.18	0.00
	Gupta, 2016	College Undergrad	Survey	-0.18	-0.24	-0.12	-5.67	0.00
	Li et al., 2017	College Undergrad	Survey	-0.17	-0.26	-0.09	-3.96	0.00
	Lin et al., 2017	College Undergrad	Survey	-0.16	-0.25	-0.06	-3.26	0.00
	Samaha et al., 2016	College Undergrad	Survey	-0.14	-0.26	-0.02	-2.26	0.02
	Chen et al., 2015	College Undergrad	Survey	-0.14	-0.22	-0.05	-3.16	0.00
	Akgul, 2016	K-12	Survey	-0.14	-0.32	-0.05	-2.92	0.00
	Dos, 2014	College Undergrad	Survey	-0.14	-0.27	0.00	-1.95	0.05
	Dayapoglu et al., 2018	College Undergrad	Survey	-0.12	-0.22	-0.02	-2.28	0.02
	Walsh et al., 2013	College Undergrad	Survey	-0.12	-0.21	-0.03	-2.64	0.01
	Jankovic et al., 2016	College Undergrad	Survey	-0.11	-0.20	-0.02	-2.45	0.01
	Gi, 2016	K-12	Survey	-0.10	-0.14	-0.05	-4.42	0.00
	Junco et al., 2012	College Undergrad	Experiment	-0.09	-0.14	-0.04	-3.55	0.00
	Pecor et al., 2016	K-12	Survey	-0.09	-0.16	-0.01	-2.13	0.03
	Ishii, 2011	IK-12	Survey	-0.07	-0.18	0.04	-1.23	0.22
	Beland et al., 2016	K-12	Survey	-0.06	-0.06	-0.05	-20.61	0.00
	Jacobsen et al., 2011	College Undergrad	Survey	-0.05	-0.11	0.02	-1.47	0.14
	Harman, 2011	College Undergrad	Survey	-0.05	-0.22	0.14	-0.48	0.63
	Jackson et al., 2011	K-12	Survey	-0.03	-0.12	0.06	-0.66	0.51
	Flora et al., 2012	College Undergrad	Survey	-0.01	-0.16	0.13	-0.19	0.85
	Wentworth et al., 2014	College Undergrad	Survey	0.01	-0.08	0.10	0.22	0.83
	Rshid et al., 2016	College Undergrad	Survey	0.060	-0.01	0.13	1.65	0.10
	Hsiao et al., 2017	College Undergrad	Survey	0.094	-0.08	0.26	1.09	0.28
Fixed				-0.068	-0.07	-0.06	-26.33	0.00
Random				-0.162	-0.20	-0.13	-9.14	0.00

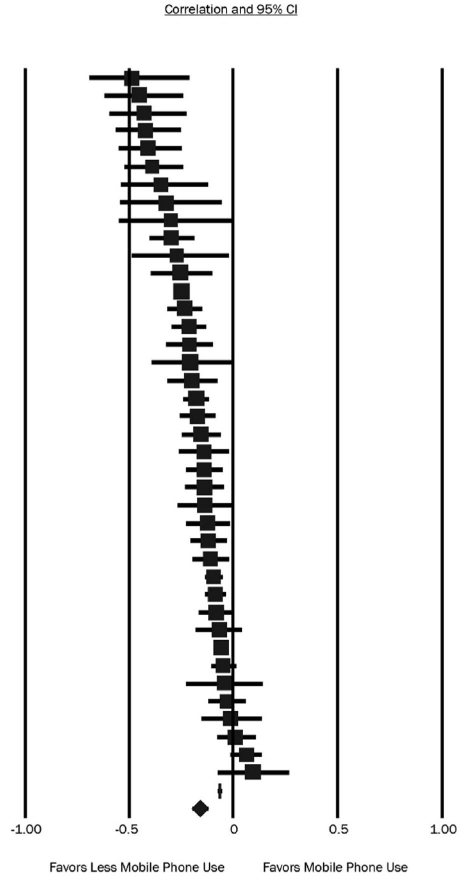

Fig. 1. Forest plot of overall effect meta-analysis.

−0.34 and upper limit of 0.02. was calculated. Based on this estimate, 95% of all true effect sizes should fall within these limits.

4.3. Test for publication bias and outliers

The asymmetric funnel plot revealed the possibility of publication bias, with a majority of smaller studies clustering to the left of the mean. Egger's test confirmed the visual inspection (t [38] = 4.89, $p < .001$). However, Rosenthal's fail-safe $N = 4{,}998$, suggests that there would need to be nearly 4,998 studies added to the analysis before the cumulative effect would become statistically nonsignificant. Given that only 39 studies were located, it is unlikely that such large a quantity of studies was overlooked. The complete meta-analysis under the fixed-effect model showed a negative association of −0.07 between mobile phone use and student academic outcomes. The meta-analysis based on the 11 largest studies reported a similar association of −0.06. Similarly, the *Trim and Fill* method suggested that if we removed the asymmetric studies, the correlation would be reduced to −0.07.

4.4. Subgroup analysis

Although overall effects have descriptive value, the I^2 statistic indicates that a large proportion of the variance in observed effects sizes is due to factors other than sampling error. The observed variability makes it unlikely that the same effect was present under all conditions. Therefore, the hypotheses that effect size might be moderated by (a) education level, (b) region, (c) study type, and (d) whether or not the effect size was derived from a Beta coefficient, and (e) smartphone construct were tested. Table 1 summarizes the results of these analyses.

The moderator analysis revealed a mean correlation of −0.17 for college students and −0.12 for K-12 students, suggesting that mobile phones have a somewhat larger negative influence on college students than on K-12 students. The between-groups homogeneity statistic (Q_B) was used to test the group difference. Q was not statistically significant at $p < .05$, thereby indicating no significant difference in between-group effects.

Regional differences in effect size were also examined. The mean correlations were −0.11 in Middle Eastern students, −0.13 in Asian students, −0.16 in “other”, and −0.20 in the United States. However, no statistically significant regional group differences were found ($Q_B = 3.95$, $p = 0.27$).

Table 1
Summary statistics for moderators.

Moderator	k	r	95% CI		Z	Q_B	R^2
			LL	UL			
Education Level						1.83	8.3%
University	32	−0.17	−0.21	−0.14	−8.83***		
K-12	8	−0.12	−0.19	−0.05	−3.39***		
Design						10.43**	0
Experiment	8	−0.30	−0.38	−0.21	−6.40***		
Cross-Sectional	32	−0.14	−0.18	−0.10	−7.22***		
Region						3.95	0
Asia	7	−0.13	−0.21	−0.05	−3.03**		
Middle East	6	−0.11	−0.20	−0.02	−2.29*		
Other	5	−0.16	−0.26	−0.06	−3.00**		
USA	22	−0.20	−0.25	−0.15	−7.45***		
Beta-Based Effect Size						20.46***	53%
No	29	−0.20	−0.23	−0.17	−11.59***		
Yes	11	−0.07	−0.12	−0.03	−3.04**		
Mobile Phone Use Construct						11.21*	0
Exposure vs Non-Exposure	12	−0.28	−0.35	−0.20	−6.83***		
Frequency Scale	9	−0.12	−0.19	−0.04	−2.95**		
Mobile Phone Addiction/Problematic Use	7	−0.12	−0.20	−0.03	−2.58*		
Total Time Spent	12	−0.15	−0.22	−0.09	−4.64***		

Note: random effects model; *$p < .05$; **$p < .01$; ***$p < .001$.

Another concern was whether the effect sizes were moderated by research design. As shown in Table 1, there was a statistically significant difference between the correlation coefficients of cross-sectional studies ($r = -0.14$) and experimental studies ($r = -0.30$), where $Q = 10.43$, $p < 0.01$. In the studies where effect size was derived from a regression model beta-coefficient, the mean correlation coefficient tends to smaller (r = −0.07) than other studies (−0.20). The Q_B was statistically significant ($Q_B = 20.46$, $p < 0.001$) showing that average effect size differed significantly with the category. The R^2 was 0.53, meaning that 53% of total between-study variance in effects can be explained by the form of effect size. It was also confirmed that the construct used to measuring mobile phone usage moderates effect size. The largest negative correlation was found when the smartphone usage was measured by a binary construct (e.g. exposure vs. non-exposure) ($r = -0.28$), while the smallest coefficient was found when smartphone use measured by frequency scale of mobile phone use ($r = -0.12$) and the levels of mobile phone addiction or problematic use ($r = -0.12$). The Q_B indicated a statistically significant difference between groups ($Q_B = 11.21$, $p < 0.05$).

5. Summary of results and discussion

This meta-analysis was designed to explore the extent to which mobile phone use influences student academic achievement, and if so, the extent to which the effects of mobile phone use are moderated by (a) education level, (b) region, (c) study type, (d) whether or not the effect size was derived from a Beta coefficient, and (e) the construct used to measure mobile phone use.

The results of this study indicate that, overall, mobile phone use has a small negative effect ($r = -0.16$) on educational outcomes which is consistent with the previous literature (Lepp et al., 2015; Li et al., 2015). However, the results caution against coming to hasty conclusions based on these findings. The summary effect size is relatively small, even in the educational sphere. Hattie (2012), for example, conducted over 900 educational meta-analyses and found the largest summary effect for a classroom intervention to be a Cohen's d of 1.44. Taking this into account, it is not surprising that something so ubiquitous and increasingly integral to students' lives would have some influence on educational outcomes. Additionally, although the publication bias analysis suggests that these results are not greatly biased by a systematic exclusion of studies, it should be noted that the effects observed could be indicative of an association rather than causation. For example, those who are predisposed to overuse mobile devices may simply be less likely to achieve academically in the first place. That the summary effect is derived from studies involving experimental groups as well as cross-sectional studies, however, brings this possibility into question.

These findings appear most generalizable to the secondary and university educational levels, as these comprise the entirety of the sample. Most students in these studies ranged from early teens through late-twenties. These results may not be generalizable to older non-traditional students, nor to Pre-K or elementary students. For the subgroup analyses, there was a lack of evidence to support that the effect of mobile phone use was moderated by participants' background variables (educational level and region). However, research design (cross-sectional vs. experimental), the source of effect size data (beta coefficient-based vs. not), and the construct used to measure mobile phone use (exposure/non-exposure condition vs. frequency scale, vs. total time spent, vs. mobile phone addiction/problematic use) all yielded statistically significant differences between groups when examined in moderator analyses. This finding suggests that the variation in observed effect of mobile phone use could primarily be related to research design. Thus, for further meta-analyses, we urge researchers to pay close attention to elements of research design in the included studies. While 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 phones detected by empirical studies.

This study has several limitations. First, given the high diversity of constructs examined for mobile phone use in this study, as well as diversity of settings, it was unlikely that a single summary effect could be found. Even within-group variability proved to be high for almost all groups in moderator analyses. A second limitation of this study was the quality of the included studies. While the sample included some high-quality studies with large sample sizes and narrow confidence intervals, there were a number of studies that did not possess these favorable characteristics. However, the summary effect relies largely on these large, high-quality studies and is not greatly affected by these smaller studies.

Despite the variability between studies, there appears to be a consistent negative, albeit small, effect on educational achievement. This suggests that avoidance of mobile phones in educational settings, or for those who are currently in school, could be beneficial for academic achievement. However, educators may want to concentrate on interventions that yield a higher effect size. It is possible, for instance, that the active integration of mobile devices into the classroom as educational tools could undo a portion of the negative effects of normal mobile phone use. For example, Schmid et al. (2014) in a meta-analysis of technological interventions in post-secondary education found a summary effect of 0.27 (Hedge's *g*), while Tingir, Cavlazoglu, Caliskan, Koklu, and Intepe-Tingir (2017) found an effect of 0.54 for mobile devices in general, and 0.45 for mobile phones in particular (hedge's g). In short, mobile phones are not to be seen necessarily as an educational scourge, but simply one of many factors to consider when making educational choices for oneself, one's family, and the classroom.

Further research is needed to explore the contextual factors that moderate the effects of mobile phone use on educational outcomes. Additionally, studies are needed to examine the difference between mobile phones' effects on educational outcomes where casual use and educational use is compared.

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