Problematic Mobile Phone Use in Secondary Mathematics Classrooms

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Abstract: Mobile phones have become increasingly more commonplace in everyday life, resulting in unprecedented student distraction and behavioral addiction in the classroom environment. Further, problematic use of mobile phones has been shown to be closely related to cognitive health and wellbeing, particularly in terms of anxiety, depression, academic stress, and psychological disequilibrium. Since the inception of the smartphone in the early 2000s, increases in mobile phone use have coincided with students' difficulty in meeting increasingly rigorous mathematical standards. Therefore, this quantitative study sought to determine whether a significant relationship exists between Problematic Mobile Phone Use and two cognitive wellbeing outcomes of procedural fluency and conceptual understanding. A compound theoretical framework offers insight into germinal and current theories based on the established key tenets of behavior, distraction, and policy. The descriptive correlational design assessed potential relationships between problematic mobile phone use and these two cognitive wellbeing outcomes. A stratified sample of educational leaders from five school sites participated in the Student Mobile Phone Use Survey (SMPUS), yielding data about leaders' impressions of students' Problematic Mobile Phone Use. Results from statistical tests showed that problematic use showed a significant negative association with students' conceptual understanding, but no significant association with their procedural fluency. Given that problematic phone use is closely tied to students' cognitive wellbeing, the results of this study have implications beyond mathematical proficiency to include all aspects of a student's cognitive and emotional health. Recommendations to practitioners include formulating focus groups and professional learning communities around mobile phone policy and instructional development to address and support students' cognitive wellbeing.

Keywords: Conceptual understanding, Distraction, Policy, Problematic mobile phone use, Procedural fluency.

INTRODUCTION

As mobile phone use has increased in society, the issue of problematic mobile phone use has become a valid concern for public health, with links to various mental health issues, such as cognitive overload, emotional stress, and behavioral addiction, anxiety, and depression. Disturbances in sleep patterns have also been associated with excessive phone use (Ndayambaje, E., & Okereke, P. U. (2025). Nonetheless, mobile phones have become increasingly present in the classroom, posing challenges for teaching and student learning (Dunn *et al*., 2013; Ni Fhloinn & Fitzmaurice, 2021). One of these challenges is student psychological well-being. Zhou *et al*. (2024) found that students often reported using their phone as a play device for satisfaction, leading to depressive onset if the phone is removed. The authors posited that middle school students' wellbeing can be improved by reducing the time of mobile phone use, along with increased social support. These strategies can then increase student wellbeing by reducing symptoms of anxiety and depression and increasing students' ability to handle academic pressure.

Problematic mobile phone use is defined as a specific type of phone-related behavior that elicits certain psychological and behavioral symptoms. PMPU has been described as pathological in nature, in which addictive symptoms and psychological distress become evident in users (Foerster *et al*., 2015; Squires *et al*., 2021). PMPU may include such phone-based activities as texting, social media, gaming, and video streaming. Symptoms of PMPU include craving, loss of control, withdrawal, negative life consequences, and peer dependence.

Given the prevalence of mobile phones in the general public, they have clearly made their way into math classrooms as well, posing issues for teaching and learning. According to the Common Core State Standards for Mathematics (2018), effective mathematical pedagogy and instruction requires the instruction of procedural fluency and conceptual understanding, thus forming the primary basis of problem solving in Mathematics. Conceptual understanding involves student comprehension of the concepts, or big ideas, while procedural fluency involves the completion of steps or procedures. Standardized tests are designed to assess students' comprehension of these learning outcomes, constituting significant indicators of a students' cognitive wellbeing.

THEORETICAL CONSIDERATIONS

The following theoretical framework for this study is based on germinal and current theories in the PMPU sub-domains of behavior, distraction, and policy as they relate to student well-being. This framework also

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explores elements of adolescent digital wellbeing, including emotional regulation, screen time as it relates to digital overload & smartphone addiction, adolescent cognitive development, and academic burnout.

ADDICTIVE BEHAVIOR

Modern literature regarding problematic mobile phone use has questioned whether problematic mobile phone use could comprise a behavioral addiction. The traditional medical definition of substance (or chemical) addiction was contrasted with this new, phone-based type of behavioral addiction, which is still not medically defined (de-Sola *et al*., 2017). However, as the PMPU problem has evolved, mounting recent evidence has validated the concept of behavioral addiction in problematic mobile phone use.

Smartphone Addiction Scales. To measure smartphone addiction, various smartphone addiction scales have been developed. One of these scales is called the Smartphone Addiction Scale - short version, or SAS-SV. Originally developed for South Korean adolescents, this scale has been used internationally in various settings. Hidalgo-Fuentes *et al*. (2025) examined the psychometric properties of the SAS-SV in the context of Honduran University students, confirming the instrument's validity while finding strong correlation between problematic smartphone use and stress, anxiety, depression. In India, the scale was used to measure psychosocial consequences of smartphone addiction, also confirming its validity and finding associations of smartphone addiction to lower age, lower education level, and more time spent on the phone (Felix *et al*., 2025). Another modern addiction scale is the Smartphone Application-Based Addiction Scale, or SABAS. Hidalgo-Fuentes *et al*. (2025) confirmed the validity and reliability of this scale, applying it to Spanish University student populations, finding strong associations with elapsed time of use, psychological distress, and fear of missing out. With regard to student impulsivity, parental rejection and level of school engagement were found to be contributing factors (Chen *et al*., 2021).

Psychological Needs. The theoretical literature regarding addictive mobile phone behavior includes the germinal Uses and Gratification Theory (UGT) and Compensatory Internet Use Theory (CUIT), both of which link users' psychological symptoms and unmet needs to their use of media. The main premise of UGT is that users of media are not passive recipients but active participants, exerting control over their choice of media and tailoring it to their own needs (Elhai *et al*., 2019). Compensatory Internet Use Theory extends the same principle as UGT to include modern media and internet-based mobile apps, positing that compensatory internet use occurs when a person makes up for unmet personal needs, such as social belonging and the prevention of negative emotions, through compulsive use of the internet (Elhai *et al*., 2019). An extension of these two theories is the more modern dependency theory, which suggests that people become dependent on their media of choice (Ungvarsky, 2020). Digital addiction therefore seems to be related to the individual's choice of media. Billieux *et al*. (2015) posited an integrative theoretical framework that contains four pathways to mobile phone addiction: impulsivity, relationship maintenance, extraversion, and cyber-addiction. Clearly, research in this domain continues to expand.

Cognitive Fatigue. Excessive use of the smartphone has been shown to be associated with cognitive fatigue. Yasin *et al*. (2023) emphasized the dangers of overuse, positing that excessive smartphone use is an independent risk factor for not only mental fatigue, but also cognitive flexibility. Since cognitive flexibility as well as cognitive load are key indicators of student wellbeing and academic success, student phone use at school must be addressed. Zhang *et al*. (2025) found that cognitive failure is an important mediating factor between problematic use and the established emotional consequences of stress, anxiety, and depression.

Academic Burnout. The digital overload and cognitive fatigue associated with PMPU can have effects on adolescents ability to handle academic-related stress. Hao *et al*. (2022) investigated different types of smartphone use and their relationship to stress and academic burnout. Findings indicated that stress and academic burnout were closely related to problematic mobile phone use and that personal resilience was a mediating factor between stress and smartphone use behaviors.

Emotional Regulation. Problematic smartphone use has been shown to be related to a student's ability to self-regulate. Results showed that self-regulated learning itself could be play a mediating role in the relationship between academic procrastination and problematic phone use (Eissa & Khalifa, 2020). Adolescent cognitive development in the form of learning self-regulation skills has been found to be related to problematic phone use. Xiao *et al*. (2025) found that the development of self-regulation skills earlier in life can prevent further escalation of PMPU in adolescents. There is also a parental element to adolescents' emotional regulation in this context. Meeus (2019) found that autonomy-supportive and restrictive parenting were negatively associated with problematic use, due to students' increased self-regulation. However, students' perceptions of their

own phone use can also be problematic. According to Rosič *et al*. (2025), students reported that they use their phone to self-regulate and view their use of the phone as beneficial to their well-being. However, this self-perceived view of digital well-being only correlated positively to the emotional domain and self-esteem, while the social and cognitive domains showed no correlation. Given the social and cognitive demands of mathematical proficiency, the lack of social and cognitive well-being as a result of excessive phone use is of utmost concern, both in terms of student well-being and academic performance.

DISTRACTION

The proliferation of mobile phones across the world has led to a preponderance of distraction in everyday life for most people. Given the increases in phone ownership and total use, distraction has become a major theoretical component in the literature regarding Problematic Mobile Phone Use. The ease and convenience of Internet-based apps has presented multiple domains of distraction, including visual, auditory, and kinesthetic. Given these sensory impacts,

PMPU has been shown to cause behavioral problems in people who exhibit significant levels of distractive symptoms (Franchina *et al*., 2018). An unprecedented increase of PMPU in adolescents has caused concern regarding student attention. Extant literature confirms a negative association between PMPU and student attention, linked to a corresponding decline in mathematical and academic achievement, as well as continuation of PMPU habits from adolescence into adulthood (Throuvala *et al*., 2021; Seo *et al*., 2016).

The Theory of Planned Behavior involves understanding human intentions as they relate to actions. The core concept of this theory is that it implies an individual's determination to behave a certain way and essentially blocking out external influences to continue with the chosen behavior. This planned behavior often leads to attention deficit, apathy towards content, distraction by others, perceived threat, and escapism (Rana *et al*., 2019). The more modern Fear of Missing Out (FOMO) Theory posits that mobile phone users often obsess with keeping up with the latest social media posts and events, resulting in compulsive checking behaviors. This “fear of missing out” therefore formed a theoretical basis for compulsive and distracted behavior (Franchina *et al*., 2018) Such distraction can therefore indicate problems students may have in relating to peers or other external stimuli.

Attention Depletion. As mobile phone use has increased, an observable decrease in student attention span is evident. In adolescents, problematic mobile phone use was found to be a negative predictor of attention and therefore mathematical achievement (Seo *et al*., 2016). Further, people with attention deficit issues were shown to be more prone to mobile phone addiction and dependence (Panagiotidi & Overton, 2022). These findings underscore the need to address the depletion of attention in the context of student mobile phone use.

Screen Time. The mental health effects of screen time are becoming increasingly apparent in the literature. Li *et al*. (2025) focused on gaming and social media use, finding that adolescents who do these activities more than an hour per day or more likely to experience depression and suicidal ideation. Some gender differences emerged, showing that girls are at more risk than boys of severe depression and suicidal ideation.

POLICY

The third component of this PMPU theoretical framework is policy. The advent of mobile phones and their predominance in society has inevitably resulted in phone use in classrooms and educational environments. Teachers, principals, and school leaders have been therefore tasked with managing this newfound problem. The creation of policy regarding PMPU requires an understanding of theoretical frameworks and pertinent evidence, empowering educational leaders to create effective policies that consider the environmental factors relating to students’ well-being and mental health.

Many different forms of mobile phone policy exist across various school systems. At the classroom level, student resistance to rules can lead to conflict with authority. These forms of student resistance may vary in levels of intensity, but are theoretically grounded in psychological response to discipline. Self-Determination Theory applies to the creation of mobile phone policies. The theory is based on three psychological needs: autonomy, competence, and relatedness, each of which provides perspective on human motivation and personality. When students feel as if these needs are being thwarted by policy, negative or resistant behaviors can result (Center for Self-Determination Theory, 2019). Both psychological reactance and self- determination theories can be synthesized to conclude that students’ psychological needs are central to understanding mobile phone policy formation and the wellbeing of individual learners.

Emotional Distress. Excessive phone use has also been shown to be related to emotional distress in

individuals. Mashtaghi *et al*. (2024) showed that problematic mobile phone use shows strong correlations with alexithymia, feelings of loneliness, and distress tolerance. Each of these variables relates directly to emotional distress, social isolation and the ability to intonate and articulate emotions. This research proves that there is an emotional component to PMPU.

STUDENT WELL-BEING

The central tenets of PMPU outlined in this theoretical framework underscore the need to integrate student health considerations into math instruction. Behavior, distraction, and policy describe much of the interface between students and authority figures with regard to PMPU. As the research has shown, student well-being is at the center of each of these theoretical domains. Therefore, a thorough understanding of student well-being is essential to math achievement.

METHODS

The methodology for this study used academic outcomes as dependent output variables. It is important to note that these mathematical learning outcomes of conceptual understanding and procedural fluency are being utilized as indicators of students' cognitive wellbeing.

VARIABLES

The set of independent variables for this study were behavioral subcomponents of problematic mobile phone use, including abuse, dependence, craving, loss of control, social dependence, desire, withdrawal, and tolerance. The dependent variables for this study were the two main elements of mathematical proficiency - conceptual understanding and procedural fluency – as measured via standardized assessment. In order to create the two composite dependent variables, a total of eight conceptual targets and eight procedural targets were aggregated for each school site. Examining potential relationships between these vital components of mathematical proficiency and PMPU in high school students, required a descriptive correlational design, utilizing statistical techniques to test for relationships among variables. Techniques for analysis included multivariate linear regression along with both non-parametric and parametric correlational tests, namely Spearman's Rho and Pearson r multivariate regression procedures. The results of these analyses were intended to provide evidence to educational leaders to support the development of policies and procedures regarding mobile phones in the classroom, student well-being, and students' learning of mathematics.

In this study, the independent variables are subcomponents of problematic mobile phone use, as measured by the Student Phone Use Impression Survey (SPUIS). This survey is modified from the MPPUS-10 derived by Foerster, *et al.* (2015) from a student self-reporting format to an educator impression reporting format regarding student symptoms and behaviors. The function of this instrument was to assess educational leaders' impressions of students' problematic phone use and resulting behaviors. It is important to acknowledge that due to ethical constriants, the modification of the original instrument was necessary to change from student self-reporting to educational leader reporting. Given this limitation, the data captured from the survey may not have fully captured students' psychological or emotional state.

The survey evaluated 10 distinct areas as identified by the Mobile Phone Problematic Use Scale (MPPUS-10). These variables include abuse, dependence, craving, loss of control, and social dependence desire, control, withdrawal, and tolerance. The dependent variables for this study are conceptual understanding and procedural fluency as mathematical learning outcomes measured on standardized tests.

SETTING

The setting for this study was a large, semi-urban school district in a Western state, containing approximately 35,000 total students. The population for this study included educational leaders who work with high school math students. The sample for this study was taken from five high school sites in the district. All necessary ethics permissions were obtained from the Institutional Review Board.

Stratified, non-random sampling allowed for the organization of leaders into three subgroups: teachers, counselors, and administrators. These leaders' impressions of student mobile phone use were then measured by a 10-item Likert-scale survey administered through a secure web-based survey platform. Due to constraints in sampling students under the age of 18, self-reporting of students was replaced by educational leaders' rating their impressions of students' phone use. Within the context of this study, the educational leadership of these three subgroups could play an important role in the development of PMPU policies and guidelines.

The teacher subgroup consisted of all high school math teachers within the district (grades 9-12). The counselor subgroup consisted of academic counselors, career counselors, and guidance counselors. Finally, the administrator subgroup consisted of site administration at each of the five high schools in the

district, including principals, vice principals, and academic administrators. A total of 103 educational leaders were selected for the sample and invited to participate in the survey. Participation rates averaged above 50%, and there was an equitable distribution of different leader types across each school in the sample. Using a 95% confidence level and a confidence interval of 10, the sample size calculator from Creative Research Systems (2020) recommended a sample size of 50-75 participants.

INSTRUMENTATION

The instrumentation for this study included the Student Mobile Phone Use Impression Survey (SMPUIS), listed in Appendix A. This survey sampled the impressions of educational leaders regarding their students' PMPU symptoms and behaviors. The impression survey was modeled after a self-reporting survey derived by Foerster *et al*. (2015), in which five PMPU factors were extracted during the derivation from the shortened Mobile Phone Problematic Use Scale (MPPUS-10).

DATA COLLECTION

Data collected from the instrumentation included a secure online survey administered through the Survey Monkey platform. Data collection was conducted for three weeks, in order to achieve the desired sample size of 50-75 participants. Data for student performance was archival and was accessed through the Test Operations Management System (TOMS) and the school district's assessment office.

The means of analyzing the data comprised a sequence of statistical analysis procedures. The average score for each behavior and symptom on the SMPUIS test resulted in a ranking of each type (symptom and behavior). The results were then categorized by educational leader type.

Given the constraint of aggregate dependent data, both non-parametric and parametric tests were used, in the forms of Spearman's Rho and Pearson's r, respectively. Since the parametric test had greater assumption requirements, it was utilized as a triangulation check on the results from the non-parametric Spearman's Rho test. Finally, the data analysis method was designed to be replicable in future studies.

RESULTS

The results of this study clearly indicate that PMPU negatively impact cognitive processing and emotional health. Annotated below are the hypothesis tests and their results.

Hypothesis Test 1: PMPU and Procedural Fluency

The first hypothesis test involved determining whether a significant relationship existed between problematic mobile phone use and students' achievement of procedural fluency, as outlined in the following research question:

RQ1: Is there a relationship between PMPU in the math classroom and students' achievement of procedural fluency?

H_o: Problematic mobile phone use in the math classroom is not related to students' achievement of procedural fluency.

H_a: Problematic mobile phone use in the math classroom is related to students' achievement of procedural fluency.

Results from the Spearman's Rho multiple regression, as shown in Table **1** (Appendix **B**), show that there is very little correlation between PMPU symptoms and procedural fluency. The individual correlation coefficients indicated little to no correlation overall with negligible values close to zero. Further, nearly all correlation coefficients were positive, indicating that there would theoretically be no deleterious effect on students' procedural fluency from these PMPU behaviors. This result is further supported by district wide procedural fluency test scores which showed that procedural fluency appears to be fairly robust and consistent across school sites and student ethnicities. This non-parametric test therefore showed very little to no correlation between PMPU symptoms and students' achievement of procedural fluency.

In order to verify these parametric results, the Pearson-r correlational test was utilized as a check for significance of association. Table **2** (Appendix **C**) shows the output for the Pearson-r multiple regression test for procedural fluency, including the analysis of variance (ANOVA).

As the table shows, the regression resulted in relatively low correlation and a low-power quantitative relationship ($r=0.589$, $F=1.647$). Finally, this hypothesis test indicated a non- significant finding with a relatively high p-value of 0.139, well above the .05 significance level. Based on the results of both parametric and non-parametric tests, the null hypothesis could not be rejected, indicating that that there is no significant association between Problematic Mobile Phone Use and students' procedural fluency in Mathematics.

Hypothesis Test 2: PMPU and Conceptual Understanding

The second hypothesis test involved the same set of parametric and non-parametric tests for assessing whether or not a significant relationship existed between PMPU and students' achievement of conceptual understanding, according to the second research question below: RQ2: Is there a relationship between problematic mobile phone use in the math classroom and students' achievement of conceptual understanding?

H_o: Problematic mobile phone use in the math classroom is not related to students' achievement of conceptual understanding.

H_a: Problematic mobile phone use in the math classroom is related to students' achievement of conceptual understanding. Table **3** (Appendix **C**) shows the results from the Spearman's Rho multiple regression.

The correlation coefficients in Table **3** exhibit a pattern in that almost every PMPU symptom and behavior had a negative correlation with conceptual understanding. The variables with the greatest magnitude of negative correlation between PMPU and conceptual understanding were 'Increased dependence on peers through phone-based interactions'(-0.152), 'Hyperactivity and loss of self-control' (-0.135 each), and 'Problems with personal conduct' (- 0.104). Further, each of these variables corresponded to those most often observed by educational leaders as sampled in the SMPUIS survey, shown in Appendix **A**.

The fact that virtually all of the independent variables showed a negative correlation with conceptual understanding indicated a common directionality effect for each individual symptom or behavior as it relates to student achievement of conceptual understanding. Given the stark contrast between the Spearman's Rho regression for procedural fluency and the Spearman's Rho for conceptual understanding, there is clearly a difference in how PMPU relates to these two metrics. Further, these non-parametric results coincide with districtwide standardized test results, which show each school and student subgroup scoring consistently lower on conceptual understanding targets than on procedural fluency targets. To confirm these non-parametric results, a Pearson-r multiple regression test was implemented, showing results in Table **4** (Appendix **D**).

Most notable in this table are:

1. the relatively high Pearson-r value of 0.700,
2. a relatively high F-statistic (2.623) indicating strong statistical power, and
3. a low p-value of 0.018 (well below the 0.05 significance level)

These three statistics indicate a statistically significant, high-power negative correlation between students' PMPU and the achievement of conceptual understanding. Thus, the parametric results listed here confirm the negative correlations found in the non-parametric Spearman's Rho test. The null hypothesis can therefore be rejected, showing that PMPU is significantly related to students' achievement of conceptual understanding.

IMPACT OF SCHOOL SITE

One of the main values of statistical testing lies within its ability to provide insight into actual situations. In this case, the statistical testing offered insight into the importance of school site as a variable. In order to ensure statistical significance, the school site needed to be considered as an input variable, along with the ten PMPU symptoms and behaviors.

Table **7** (Appendix **F**) shows the grouped mean outcomes for each school on a 1-4 scale. As the table shows, there was much more variation in the conceptual understanding scores than there were in the procedural fluency scores. Also, for all school sites, students consistently scored lower on conceptual understanding targets than for procedural targets. Further study would be needed to determine if PMPU constitutes a causal relationship with conceptual understanding.

There is an evident consistency of procedural fluency scores when compared to the schoolwide results (repeated value of 2.25 across three of the five high schools). Also, School B notably scored considerably lower than the others, as it is a non-comprehensive high school with a completely different student body profile. Despite the relative stability of procedural fluency scores across schools, there were differences in student achievement by ethnicity, as shown in Table **8** (Appendix **G**).

As the table shows, Hispanic and White students scored consistently in procedural fluency across all five high schools at 2.25. In contrast, the African-American population scored significantly lower (1.75) than their counterparts from other ethnicities in procedural fluency. In relative contrast to this juxtaposition, there appears to be a reciprocal effect with conceptual understanding for the African-American subgroup. Though this group shows lower procedural scores on average, they score higher than their white and

Hispanic counterparts in conceptual understanding (1.625 >1.375). Therefore, the African American student population seems to excel with conceptual understanding topics when compared to the other two ethnic groups.

DISCUSSION

The results indicate that each statistic indicates a more significant correlation of PMPU with conceptual understanding than with procedural fluency. In contrast to procedural fluency tasks, the cognitive load of conceptual understanding tasks can be explained by Cognitive Load Theory, which implies a taxing effect on working memory when certain concepts are taught. Moussa-Inati & Causapin (2019) found that students performed better on conceptual understanding tasks when their cognitive load was decreased, and found a negative relationship between cognitive load and conceptual understanding test scores.

Another potential explanation of this result is selective attention. Deco *et al*. (2002) found that selective attention is directly related to the visual cortex of the brain, and that an independent neural mechanism guides the search for distinct features. Due to the highly visual nature of conceptual understanding, this finding is significant. Further, since conceptual understanding tasks consist of mostly higher-order cognitive processing skills, the distractibility element of PMPU is also a factor. Awofala *et al*. (2020) went beyond visual attention to identify connected yet distinct sub-domains of digital distraction, including digital addiction, cmotional distraction, and distraction by procrastination. This extended level of personal distraction may explain the results that conceptual understanding has a much stronger relationship with PMPU than procedural fluency.

Leaders in K-12 education are expected to foster students' ability to think critically, communicate effectively, and demonstrate competency in core subjects including mathematics. As such, there is a great need to address any potential hindrance to the development of these mathematical competencies in adolescents, including PMPU. This study has drawn on germinal and current research to address the modern problem of problematic mobile phone use in educational learning environments. The literature-informed theoretical framework utilized a transformational leadership model to educate leaders and researchers about the challenges of mobile phone distraction in educational settings through data-driven and evidence-based findings. This study's results are intended to contribute to the research community while assisting educational leaders in taking proactive steps toward creating future PMPU policies.

The quantitative analysis and results from this study yielded information that showed that PMPU symptoms and behaviors are more strongly associated with students' attainment of conceptual understanding as opposed to procedural fluency. School site was also deemed to be a significant factor in determining the relationship between problematic phone use and mathematical achievement.

IMPLICATIONS

Given the impact of school site on PMPU and conceptual understanding, it is vital for educational leaders to consider the variability in school sites' instructional leadership, management of PMPU, and emphasis on student wellbeing. Based on the research conducted in this study, it is recommended that leaders conduct a collaborative approach to developing a districtwide phone policy that all school sites can agree to implement and support. Focus groups and/or professional learning communities (PLCs) at each site can brainstorm potential solutions. District leadership could then be able to utilize the data brought from these focus groups to establish PMPU norms and procedures that each school site could agree to and follow.

With regard to curriculum and instruction, educational leaders are advised to be cognizant of student wellbeing and how individual school sites are approaching the instruction of conceptual understanding in Mathematics. It is therefore recommended that district leadership meet with mathematics teachers and leaders to discuss approaches to conceptual instruction and students' cognitive, emotional, and social wellbeing. With the current curricular focus on concepts and procedures, this study could potentially impact policy that supports the achievement of these learning outcomes and future leadership development in mathematics.

From this study, there are four primary findings that apply to educational leadership:

1. Problematic mobile phone use was found to be NOT significantly associated with students' procedural fluency. Neither the Pearson-r nor the Spearman's Rho generated a significant result. Demographic test results also supported this finding across subgroups.

2. Problematic mobile phone use was found to be significantly associated with students' conceptual understanding. Both the Pearson-r and Spearman's Rho showed negative correlations of PMPU with Conceptual Understanding.

3. Conceptual understanding scores were consistently lower than procedural fluency scores at all grade levels, regardless of comparative subgroup. This is not surprising given the research by Rittle-Johnson *et al*. (2001) which found that assessment methods for conceptual understanding require higher-order thinking skills such as verbal response, knowledge of vocabulary, and articulation of reasoning. These skills require cognitive wellness, are more difficult to assess than procedural targets, and contrast with the simpler methods of assessing procedural fluency that present lower cognitive load to students.

4. According to the SMPUIS survey, the two most often-observed PMPU symptoms were students' craving use of the phone and increased dependence on peers through phone-based interactions. This last finding correlates with research by Roser *et al*. (2015), which determined that mood and psychological well-being is closely correlated with PMPU in adolescents. Both symptoms exemplify psychological risk factors, based on this a priori research.

The results from this study indicate that there are four main areas of consideration for educational leaders and practitioners. These leaders and practitioners may range from the individual teacher level to district, county, and state boards of education. Ideally, the findings of this study are best suited to provide data for those involved with organizational education at the K-12 level. However, since high school students continue most of their mobile phone routines into adulthood and post-secondary education, the findings of this study could extend into university-level student populations as well. The four areas for the district to consider are:

- Student phone craving and peer dependence through phone-based interactions
- Student attention span, distraction, and working memory
- Instructional strategies for developing students' conceptual understanding
- Classroom, Site, and District-level policies and procedures regarding PMPU

In order to implement some of these changes, a districtwide effort toward training all math teachers in conceptual understanding is necessary. Potentially, a system of professional development modules could help develop teachers' pedagogical strategies regarding conceptual understanding learning targets. As far as the student PMPU issue, findings by Burns and Lohenry (2010) indicated that mobile phone etiquette, policies, and awareness could provide potential solutions to the distraction issue. To this end, it is recommended that the district consider establishing a districtwide committee focused on PMPU in the classroom and cooperatively developing policies that the district could adopt to combat the issue of distraction and attention deficit. Ideally, this effort would begin by collecting representatives from each school site to determine how PMPU policies differ at the classroom, site, and district level.

Given these impacts, it is vital for educational leaders to consider the school sites and the variability that inevitably exists in site leadership styles and protocols. Based on the research conducted in this study, it is recommended that leaders conduct a collaborative approach to developing a districtwide policy that all school sites can agree to enforce and support. Also included would need to be discussions about the non-problematic use of phones in the classroom. It is recommended that this topic be brought forth to focus groups or professional learning communities (PLCs) composed of teachers, counselors, and administrators at each site.

Organizational leadership would then be able to utilize the data brought from these focus groups to establish agreed upon norms and procedures that each school site could follow. It may also be helpful to make up a mnemonic phrase or slogan that students and teachers can easily remember.

Based on the findings of this study, educational leaders are advised to be cognizant of how each school site is approaching the instruction of conceptual understanding in Mathematics. It is therefore recommended that district leadership meet with all mathematics leadership to discuss approaches to the teaching of the conceptual understanding targets.

LIMITATIONS

The results from the statistical tests revealed potential conclusions about problematic mobile phone use in the mathematics classroom. However, the setting for the study was limited to a single public-school district situated in a semi-urban area of a far western state. Generalizing the results of this study would need to take into consideration variability in school systems and their approaches to PMPU in the classroom. The multitude of factors influencing both

mobile phone use and mathematical performance vary greatly across school systems and must be considered as contributors to the complexity of the problem.

Beyond educational setting, there were also limitations in the data collected. First, the survey that was used was relying on educator reporting as opposed to student self-reporting. Although student self-reporting would be ideal for data collection, this modification presents a slight limitation to the data collected. Second, districtwide test score data were aggregated, *i.e*., limited to a single score for each of the five high schools. For this reason, the values in the range of this variable were repeated for several varying inputs. Each of the ten independent PMPU variables were totally variable across all participants. Without sufficient variation, many of the assumptions for testing were not able to be fully met. Each respondent had a unique input for the ten variables depending on the scaled responses of 1-10 for each participant. However, the school site and the score for that school site became fixed for groupings of participants, resulting in each school site's participants being assigned the same output score. Since the outputs were limited to five values for each test, this became a limitation statistically to fully me*et al*l assumptions. However, most of the assumptions for the Pearson-r test were met here. Therefore, the Pearson-r test and the Spearman's Rho test were both considered for triangulation purposes.

In terms of data collection, the test score data became the limitation. Ideally, each math teachers' individual Claim 1 results would be tabulated to provide more variability in the dependent variables of conceptual understanding and procedural fluency. Instead of all teachers at one site being assigned the same math score, it could be possible to sort individual results by teacher and assign those to the outcomes. However, this adjustment to the study protocol may retrograde anonymous data collection back to confidential, since personal identifiers would be necessary. This idea may be useful for future studies, in order to get more accurate data points and variability information.

One final limitation of the data collection was sample size. In this study, the sample size was 54 survey respondents (given incomplete responses). This number of respondents is just above the minimum of 50 in a regression study, according to the Central Limit Theorem. In retrospect, the desired range of 80-100 participants would have been ideal, since it would have provided more variation and increased the validity of the testing.

RECOMMENDATIONS FOR FUTURE RESEARCH

One recommendation for future research would be to continue investigating how students develop the conceptual understanding of mathematics. Since procedural fluency has been the steady focus of mathematics instruction for centuries, more research work needs to be done related to how students learn concepts, the cognitive processes and memory factors associated with these tasks, and how educators can support students in achieving conceptual understanding. More research is needed to understand the phenomenon of problematic mobile phone use as it relates to the more technical aspects of teaching and learning mathematics.

The data analysis and findings have indicated that PMPU has become increasingly common in adolescents and has a significant impact on students' ability to understand concepts in mathematics. The concept of attention deficit from PMPU needs to be further addressed in terms of students' ability to grasp mathematical concepts, whether abstract or concrete. The established theory of Fear of Missing Out is closely associated with the ignoring of one's friends or personal surroundings by paying attention to their mobile phone, also known as phubbing (Oxford, 2019). Further, Kuznekoff and Titsworth (2013) found that high-distraction mobile phone use in a learning environment caused significant learning deficits. Based on the theoretical framework and results of this study, further investigation is warranted into these distractive PMPU effects.

CONCLUSIONS

The results of this study indicate that PMPU adversely affects students' capacity to understand mathematics. The phenomena of attention deficit and cognitive dissonance that phones cause are major factors in reducing students' attainment of conceptual understanding targets. Recommendations to practitioners include considering site-level autonomy vs. District- level authority in formulating PMPU policy and conceptual understanding pedagogy.

Recommendations for further research include further study into the concept of attention deficit and peer dependence as they relate to student's math achievement.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by author.

APPENDIX A

The Student Mobile Phone Use Impression Survey (SMPUIS)

For each item, please mark the box indicating your impression of how often students at your school display the following symptoms as a result of phone use at school.

1=not often at all 10 = very often

1. Loss of self-control when using a phone
2. Social withdrawal from peers and academics
3. Negative life consequences from using the phone
4. Craving the use of the phone when they can't use it
5. Dependence on peers through phone-based interactions
6. Signs of emotional distress
7. Problems with personal conduct
8. Hyperactive behavior, including verbal and/or physical symptoms
9. Problems relating to peers
10. Pro-social behavior

APPENDIX B

Table 1: Spearman's Rho Correlation Coefficients for Procedural Fluency

Problematic Mobile Phone Use Predictor Variable	Correlation Coefficient
Loss of self-control	.184
Social withdrawal from peers and academics	.110
Negative life consequences	.033
Craving use of the phone when they can't use it	-.017
Increased dependence on peers through phone-based interactions	.090
Signs of emotional distress	.208
Problems with personal conduct	.232
Hyperactive symptoms (verbal or physical)	.033
Problems relating to their peers	.019
Pro-social behavior	.162

APPENDIX C

Table 2: Pearson-r Regression Model: PMPU and Procedural Fluency

Statistic	R	F	p
Value	.589	1.647	0.139

Note: R=Pearson Correlation Coefficient, F = F-statistic, p = Significance Level

APPENDIX D

Table 3: Spearman's Rho Regression Results: PMPU and Conceptual Understanding

Problematic Mobile Phone Use Predictor Variable	Correlation Coefficient
Loss of self-control	-.135
Social withdrawal from peers and academics	-.014
Negative life consequences	-.040
Craving use of the phone when they can't use it	-.040
Increased dependence on peers through phone-based interactions	-.152
Signs of emotional distress	.042
Problems with personal conduct	-.104
Hyperactive symptoms (verbal or physical)	-.135
Problems relating to their peers	.002
Pro-social behavior	-.073

APPENDIX E

Table 4: Pearson-r Regression Model: PMPU and Conceptual understanding

Statistic	R	F	p
Value	.700	2.623	0.018

Note: R=Pearson Correlation Coefficient, F = F-statistic, p = Significance Level

APPENDIX F

Table 5: Pearson-r Correlation Coefficients: Conceptual Understanding

Problematic Mobile Phone Use Predictor Variable	UnstanStandardized B
(Constant)	1.964
School Site	-.097
Loss of self-control	-.033
Social withdrawal from peers and academics	.068
Negative life consequences	.004
Craving use of the phone when they can't use it	-.039
Increased dependence on peers through phone-based interactions	.001
Signs of emotional distress	.000
Problems with personal conduct	-.009
Hyperactive symptoms (verbal or physical)	-.001
Problems relating to their peers	-.016
Pro-social behavior	.018

APPENDIX G

Table 6: Multiple Regression Model Variable Descriptors

Predictor Variable	Value Represented
x1	School site
x2	Loss of Self-Control
x3	Social Withdrawal from Peers and Academics
x4	Negative Life Consequences
x5	Craving use of the Phone when they can't use it
x6	Increased dependence on peers through phone-based interactions
x7	Signs of Emotional Distress
x8	Problems with Personal Conduct
x9	Hyperactive Symptoms (either verbal or physical)
x10	Problems relating to their peers
x11	Pro-social Behavior.

APPENDIX H

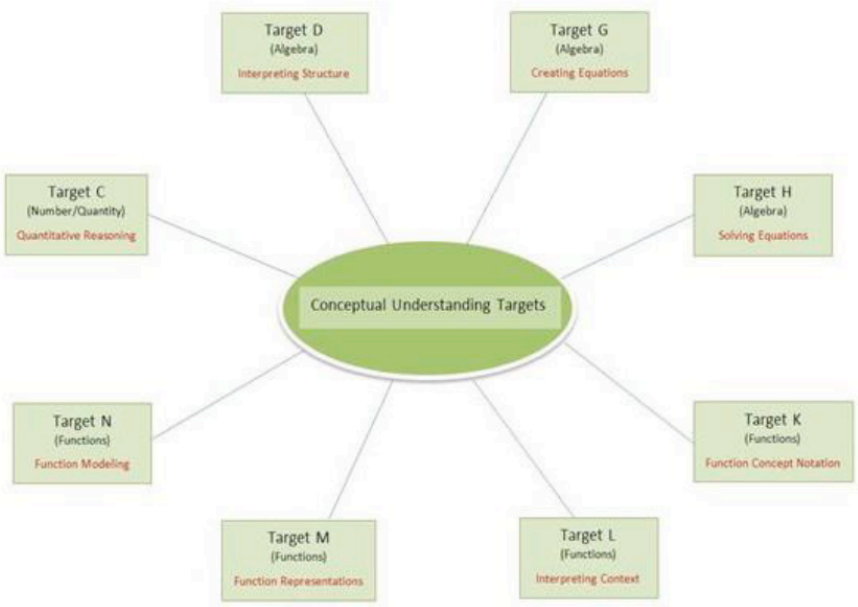

Figure 1: SBAC Claim I Conceptual Understanding Math Targets.

APPENDIX I

Table 7: Conceptual & Procedural SBAC Target Scores (by School Site)

High School Site	Students tested	Conceptual Targets	Procedural Targets
School A (pilot)	463	1.875	2.25
School B	122	1.625	1.75
School C	498	1.375	2.25
School D	544	1.625	2.25
School E	395	1.625	2

APPENDIX J

Table 8: Conceptual and Procedural Target Scores (by Ethnicity)

Ethnicity	Students Tested	Conceptual Targets	Procedural Targets
Hispanic / Latino	1542	1.375	2.25
Black / African-American	280	1.625	1.75
White / Anglo	150	1.375	2.25

APPENDIX K

REGRESSION MODEL EQUATION

Since the multiple regression analysis produced a significant result for conceptual understanding, analysis of the regression model correlation coefficients was necessary. The general form for multiple regression equations starts with a constant and then adds consecutive products of coefficients and input variables. The general form for a multiple regression model is: $y =$

$b_0 + b_1x_1 + b_2x_2 + b_3x_3 + \cdots + b_nx_n$, in which b0 represents the constant value, b1 represents the coefficient of variable x1, b2 represents the coefficient of variable x2, and so on. In this model, n represents the total number of predictor variables. Here, the value of n is 11, comprised of the 10 PMPU survey variables plus the demographic school site variable (x1 in this case). It is important to remember that each coefficient describes a relationship in which it is assumed that all other variables are controlled for. In other words, if a negative coefficient exists, the magnitude of that coefficient will dictate the degree to which the corresponding variable causes a loss in conceptual understanding. The items with positive coefficients are therefore of less interest, since they would not reasonably contribute to a gain in conceptual understanding. In order to generate the regression model equation for the conceptual understanding hypothesis, the following table provides the constant and coefficients for each variable. Note that the 'Unstandardized B Column' in Table **5** denotes mostly negative correlations, and form the set of coefficients for the Pearson-r regression model equation.

The 'Unstandardized b' column shows that 1.964 is the b_0, or constant value of the function, followed by coefficients for each of the independent variables in the model. The negative coefficient values indicate that the corresponding variable is negatively associated with conceptual understanding. The largest negative coefficients were -.097 (school site), -.039 (craving) and -.033 (loss of self-control), indicating that these three variables are critically important in explaining the variance of performance in conceptual understanding across school sites. The variables in this model are summarized in Table **6**.

Matching the correlation coefficients with these predictor variables, the multiple regression equation for the conceptual understanding hypothesis would be:

$$y = 1.964 - .097x_1 - .033x_2 + .068x_3 + .004x_1 - .039x_5 + .001x_6 + .000x_7 - .009x_8 - .001x_9 - .016x_{10} + .018x_{11}$$

Given the limitations of the data in terms of both sample size and aggregate test score values, both the Spearman's and Pearson's correlations were necessary. Each statistical test indicated a much higher association with PMPU for the conceptual understanding variable than the procedural fluency variable, which showed little to no correlation. Thus, both tests confirmed that PMPU is significantly related to students' conceptual understanding of Mathematics.

Since conceptual understanding was found to be significantly related to PMPU, eight conceptual understanding targets were isolated from the other eight procedural fluency targets. Figure **1** shows names of the eight SBAC conceptual understanding targets along with brief descriptors. The eight conceptual targets are shown here to iterate that these are the areas for which remediation and intervention would be necessary.

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