Research Article

Exploring Preservice STEM Teachers' Smartphone Addiction

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ABSTRACT

Smartphones are mobile technology cutting-edge. Daily, the amount of time spent on a phone increases. Excessive smartphone use and addiction have developed into big social issues. Addiction to smartphones is a negative and pathological concept that is assessed by a set of subjective and behavioral symptoms including fixation, loss of control, and withdrawal symptoms. Teachers in STEM fields have a higher degree of involvement with their students in the use of digital tools. STEM teacher candidates must demonstrate an understanding of how to incorporate technology successfully into classroom activities. Determine the incidence of smartphone addiction among prospective STEM educators to justify future awareness training. The association between pre-service STEM instructors' smartphone addiction was studied. The research included 242 persons, 180 of whom were females and 62 males. The SAI is self-administered and scored independently for each dimension. Data is analyzed using machine learning techniques. Cluster analysis is used to analyze the inventory's dimensions. The k-means technique is used for cluster analysis. The library's SHAP (SHapley additive explanations) approach was used to evaluate the classification result and assess the impact of attributes on the classification result. According to the findings, the highest level was judged to be 30 participants. Approximately 3%4 participants are deemed moderate (high and very high). Also, 48 people are at a low level. In terms of the overall group, it is modest. Being in the lowest cluster is linked to 100+ uses, whereas being in the highest cluster is linked to 6-10 uses. The exact degree of smartphone use linked to smartphone addiction is unknown. Females inversely correlate with the highest and lowest clusters.

Keywords: smartphone addiction, pre-service teachers, machine learning algorithm, cluster analysis

INTRODUCTION

Technological advancements have ushered in an open revolution in education, with new technologies emerging in teaching and learning, such as e-learning, m-learning, collaborated learning, and blended learning which have all become vital parts of technology in education (Abubakar Ismaila et al., 2019). Mobile device use has increased in popularity as a result of these learning processes (Criollo-C et al., 2021). Smartphones are the cutting-edge of mobile technology. Their popularity has been fueled by the proliferation of mobile applications.

The smartphone offers several advantages, including immediate communication and access to information from virtually anywhere via a simple, graphical, finger-based interface. A single smartphone reduces the need for many devices such as a phone, camera, speakers, WiFi adaptor, and GPS system. The user of a smartphone is able to download and execute programs (apps). Sensors integrated inside the device can offer measurements and contextual information, and by integrating communications into an app, the user requires no networking expertise (Bauer et al., 2020).

Every day, the amount of time spent on the phone grows. Smartphone users nowadays check their phones first thing in the morning and last thing before going to bed (Caliskan et al., 2019; Lin et al., 2014). Excessive smartphones use and even smartphone addiction, a type of technology addiction, have become major global social concerns as a result of rising smartphone prevalence. One type of technology addiction is referred to as "smartphone addiction" (Lin et al., 2016). Recent study has stressed the similarities between excessive smartphone use and behavioral addiction (Kwon et al., 2013; Lin et al., 2015; Panova & Carbonell, 2018; Razumovskaya et al., 2018; Tugun et al., 2020).

As a result, the usage of cellphones and tablets in schools and colleges is increasing every day, not just in free time but even during class. If cellphones are often used in class for purposes unrelated to the topic, students are likely to be distracted during lectures or activities, as they frequently overestimate their capacity to multitask, which can lead to academic underperformance (Felisoni & Godoi, 2018).

In the context of the COVID-19 epidemic, it is still unclear if smartphones are a valuable resource for student when it comes to utilizing them properly. As a result, it is still unclear whether the usage of cellphones by students enhances or detracts from their academic performance (Mella-Norambuena et al., 2021). Teachers in STEM professions have a greater level of interaction with pupils about the usage of technology tools. STEM teacher candidates are required to understand how to use technology effectively into their course activities. Determining the prevalence of smartphone addiction among potential STEM instructors might serve as a justification for future awareness training. Thus, the purpose of this study is to examine the smartphone addiction of preservice STEM teachers. Which characteristics of students are most useful in diagnosing high and low levels of mobile phone addiction will be identified in the study?

According to ASAM (2019), "addiction is a treatable, chronic medical disease involving complex interactions among brain circuits, genetics, the environment, and an individual's life experiences." Addiction to smartphones is characterized as a negative and pathological idea that is evaluated by a system of subjective and behavioral symptoms such as obsession, loss of control, and even withdrawal symptoms (Gezgin, 2018; Kwon et al., 2013).

Different self-report methods have been used to determine the prevalence of smartphone addiction (Carbonell et al., 2018; Lin et al., 2016). In a 2013 research conducted in Korea by the Korean Ministry of Gender Equality and Family, 17.9% of Korean teenagers were found to be addicted to smartphones (Mok et al., 2014). Another research in Turkey found that 39.8% of a sample of 319 Turkish university students (mean age=20.5 years) were heavy smartphone users (SAS scores ≥median median) (Demirci et al., 2015). A high level of smartphone addiction was found in 11.2 percent of 276 African American college students (ages 17-30) (≥90th percentile SAS-SV score) (Lee, 2015).

Students report three times each class on average, while the actual observed rate is close to astounding twenty-one times (Felisoni & Godoi, 2018). Excessive use of smartphones by university students negatively affects their academic success (Felisoni & Godoi, 2018; Lepp et al., 2014), sleep quality (Demirci et al., 2015; Randler et al., 2016), and psychological health (Elhai et al., 2017; Gokcearslan & Oberst, 2018; Lepp et al.,

2014). Additionally, smartphone use has been linked to neck and shoulder pain as a result of the user's posture when using the device (Shan et al., 2013).

According to surveys performed in a variety of countries (Alkhunaizan, 2019; Ching et al., 2015; Gecgel, 2020; Vezzoli et al., 2021), across the world, adolescents and university students are spending an increasing amount of time on their smartphones, and these devices have become an integral part of their life. According to Alkhunaizan's (2019) findings, university students mostly utilize their cellphones to access social media platforms like WhatsApp and Twitter. The least amount of time was spent on applications such as news and clock. Pre-service teachers mostly use the phone to share on social media tools such as Instagram (Romero-Rodríguez et al., 2020).

Numerous further researches (Elhai et al., 2017; Haug et al., 2015; Matar Boumosleh & Jaalouk, 2017; Soomro et al., 2019) have examined the frequency of smartphone addiction behaviors in younger age groups. Due to the fact that these studies analyze smartphone addiction using distinct methodologies, it might be challenging to compare the prevalence estimates given in these researches. However, it also provides information regarding addiction education based on the scales' results. The present study endorsed that like other parts of the world Saudi Learners are also addicted to the smartphones (Alkhunaizan, 2019).

Specifically, studies examining prospective teachers' smartphone addictions were also conducted. In terms of socio-demographic factors, age was a differentiating factor in smartphone addiction (Romero-Rodríguez et al., 2020). There was no substantial difference in terms of smartphone addiction between males and females (Arnavut et al., 2018). Another factor is related to the usage time. It has been a consistent indicator of these addictive characteristics that more use results in increased addiction (Romero-Rodríguez et al., 2020). Positive and substantial effects of extensive social media use on smartphone addiction have been demonstrated (Arnavut et al., 2018; Romero-Rodríguez et al., 2020).

It is stressed that evaluating what constitutes a high or low degree of SAI varies according to social context (Lin et al., 2014). Additionally, regular use of mobile devices and smartphones has expanded in obligatory distant education with COVID-19 (Mella-Norambuena et al., 2021). In this scenario, the level requirements may vary depending on the group's unique circumstances. In this study, group-based analyses were conducted to identify students' addiction levels using clustering algorithms.

METHODOLOGY

In this study, a relational descriptive method is used. The relationship between the variables of smartphone addiction levels of pre-service STEM teachers was examined. The study includes prospective teachers in the fields of STEM studying at the Russian Kazan Federal University. Students enrolled in STEM-related departments at the university are included in the study, as is the researcher, who is responsible for data collecting using a simple sampling approach. Permissions were received from the faculty administration prior to implementing the scale. The sample of the study is the volunteer students participating in the study. In the scale implementation, no data was collected to reveal the identities of the students.

Of the 242 people who participated in the study, 180 were female (74.38%, age=20.44±1.24) and 62 were male (25.62%, age=20.69±1.67). The distribution according to grade level is 1st grades (42.15%), 2nd grades (23.55%), 3rd grades (17.77%), and 4th grades (16.53%).

Data Collection Tool

Smartphone addiction inventory used to determine the level of addiction. The inventory was developed by Lin et al. (2014). The original inventory comprised 26 items that were originally categorized into four dimensions: functional impairment (eight items), withdrawal (six items), compulsive behavior (nine items), and tolerance (three items). This is adapted in the Russian context by Bayanova et al. (2022). SAI consist of 14 items and three factors: "functional impairment", "anxiety", and "compulsive behavior". Validity and reliability studies of the inventory were conducted in the context of Russia (Bayanova et al., 2022). Cronbach's alpha for functional impairment is 0.85, anxiety is 0.854, and compulsive behavior is 0.771. The SAI is self-administered, Likert type and it is scored for each dimension separately. There are also items related to the demographic variables and visual analogue scale (**Appendix A**).

Table 1. Skewness and kurtosis for the measurements

	Functional impairment	Anxiety	Compulsive behavior
Valid	242	242	242
Missing	0	0	0
Mean	15.401	10.690	6.401
Standard deviation	5.329	3.199	2.492
Skewness	0.127	-0.210	0.402
Standard error of skewness	0.156	0.156	0.156
z-score	0.814	-1.346	2.577
Kurtosis	-0.779	-0.672	-0.613
Standard error of kurtosis	0.312	0.312	0.312
z-score	2.497	2.154	1.965

Data Analyses

Firstly, we check the measurements have a normal distribution or not? The z-score of skewness and kurtosis is check for normality assumptions (**Table 1**). According to Kim (2013), the number of samples is between 50 and 300, z-score should not bigger than 2.96. As shown in **Table 1**, z-scores are not bigger than critical value. So, it is accepted that the measurements have normal distribution.

Machine learning algorithms are applied to analyze the data. All codes were worked on python in Google Colaboratory Platform. Scikit-learn (Scikit-Learn, 2021) and XGB library (XGBoost Developers, 2021) are used. Based on dimension measurements of the inventory, cluster analysis is applied. For cluster analysis, one of machine learning algorithms, k-means method is used. The k-means method is a basic iterative clustering technique that uses a simple iteration process. Calculate the distance mean using the distance as the metric and given the K classes in the data set. This will give you the initial centroid, and each class characterized by the centroid will be described by the distance mean (Syakur et al., 2018; Yuan & Yang, 2019).

To begin, the measurements were transformed into standard scale. The elbow approach was then used to identify the optimal number of clusters. Then, using the optimal number of clusters, the k-means method was used to decide which group the participants belonged to. We choose a cluster with the highest and lowest level of smartphone addiction. The XGB classifier algorithm is used to ascertain which demographic characteristics and smartphone usage habits are associated with being at the top level. The technique SHAP (SHapley additive exPlanations), which is implemented in the library (Shrikumar et al., 2017), was utilized for interpretation of classification result and evaluation of the effect of characteristics on the classification result. It makes it possible to explain the output of any machine learning model in detail (Ekaterina et al., 2019).

FINDINGS

K-Means Cluster Analysis

Since the number of questions in the subscale was different, it was converted to a z-score before the k-means analysis. According to elbow method result, there are six clusters for optimum results (**Figure 1**).
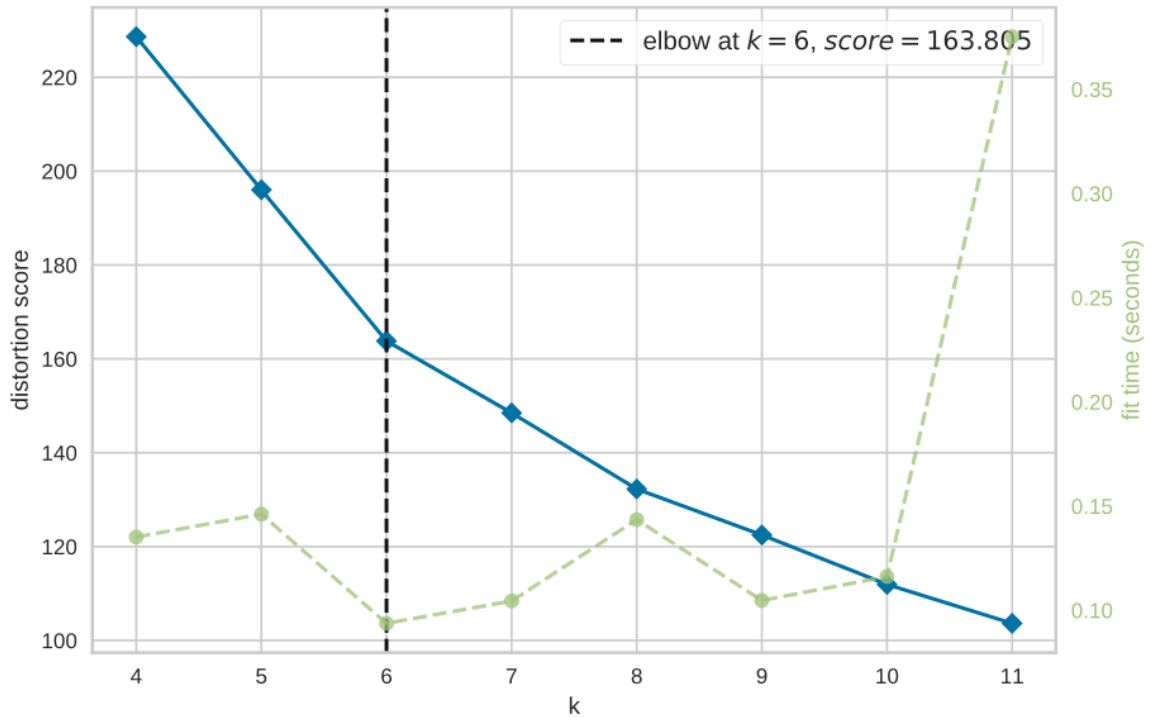
**Figure 1.** Distortion score elbow for k-means clustering

Table 2. The means of each measurements

Clusters	Average anxiety	Average compulsive behavior	Average functional impairment	Average total	N
Very high	15.03	10.47	22.97	48.47	30
High	12.96	7.44	18.89	39.30	54
Over moderate	8.14	7.40	17.46	33.00	35
Moderate	10.63	3.92	15.29	29.84	38
Low	11.65	6.54	10.76	28.95	37
Very low	6.58	3.81	8.92	19.31	48

We determined each participant clusters based on k-means algorithm. Clusters were named as "very high", "high", "over moderate", "moderate", "low", and "very low". Means of each cluster are in **Table 2**.

30 participants are determined as highest level. Approximately 34% participants are determined as over moderate (high and very high). Also, 48 participants are at very low level. Considering the general group, it corresponds to the moderate level.

There are positive relations between each dimension. In each pair-chart, distributions of measurements are examined, while the score participants from high cluster have higher and score of participants from lowest cluster have low. It means that in each measurement very low cluster has lowest score and very high cluster has highest score. **Figure 2** depicts the scatter plot of each measurement based on clusters.
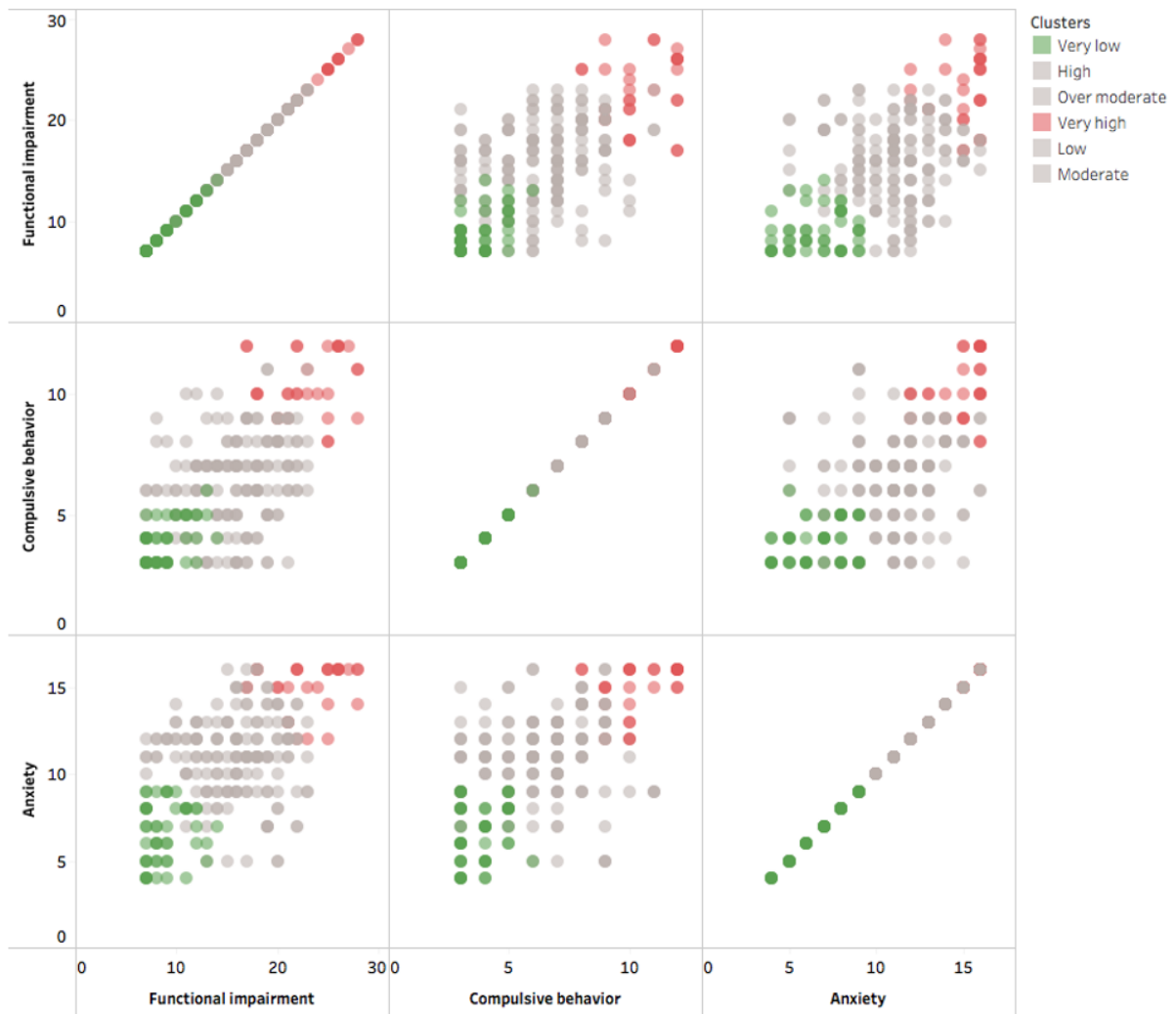
Figure 2. Scatter plot of each measurement based on clusters

The visual analogue scale has five items related to smartphone addiction (**Figure 3**). The scores of smartphone inventory subscales and visual scale questions were compared with a scatter plot. A different color was used for each cluster to determine whether there was any observable differentiation between high and low groups. As can be seen in each chart, the very low group and the very high group are positioned very differently from others. This shows that the separation of very high and very low groups is done effectively.

Figure 3. Visual analogue scale score based on highest and lowest clusters

Features Determination

Participants were divided into two groups as test and train at 0.30 ratio. Accuracy score for highest cluster is 0.904 and for lowest cluster is 0.836. Weighted average of F1-score is 0.87 for highest cluster and 0.80 for lowest cluster (**Figure 4**).
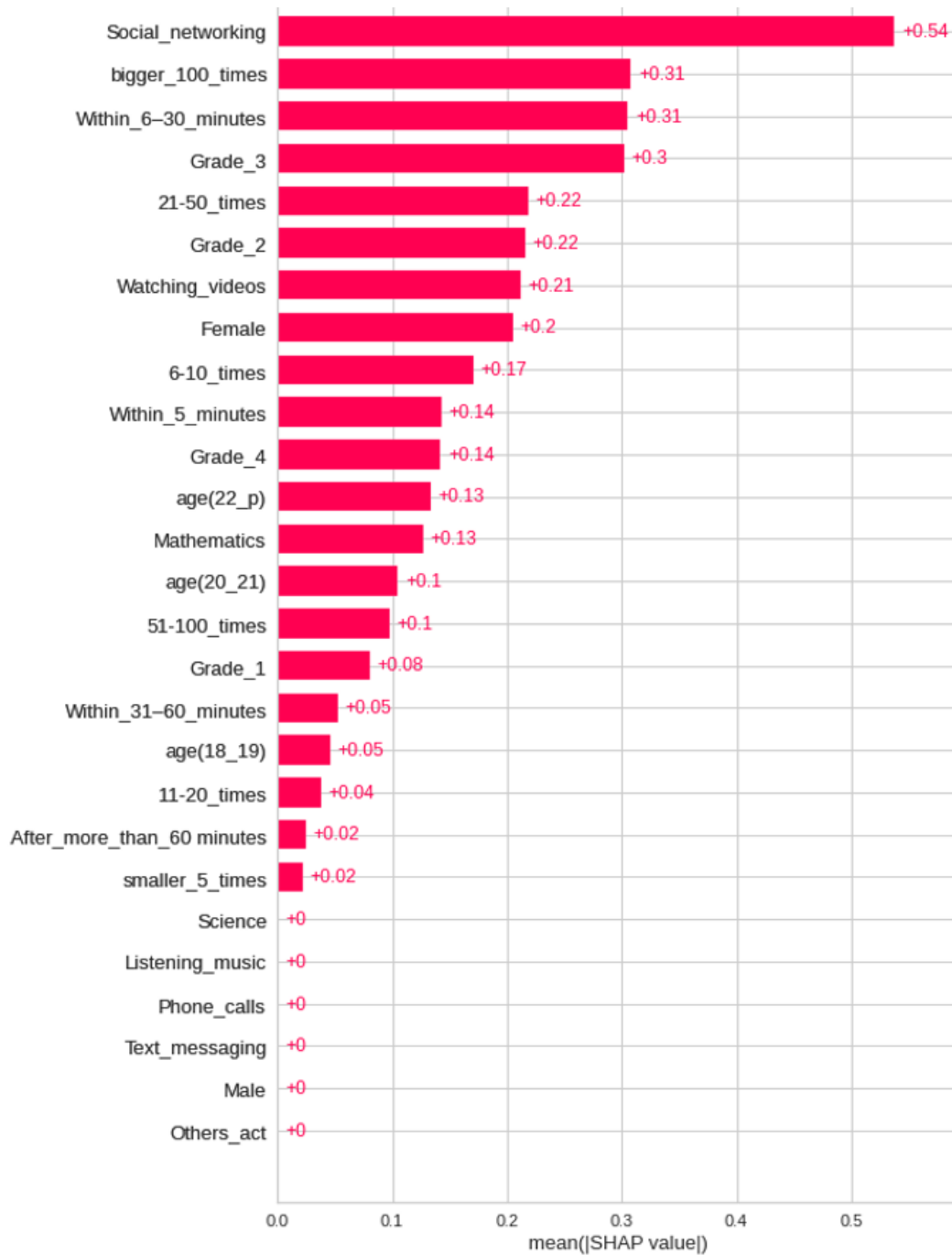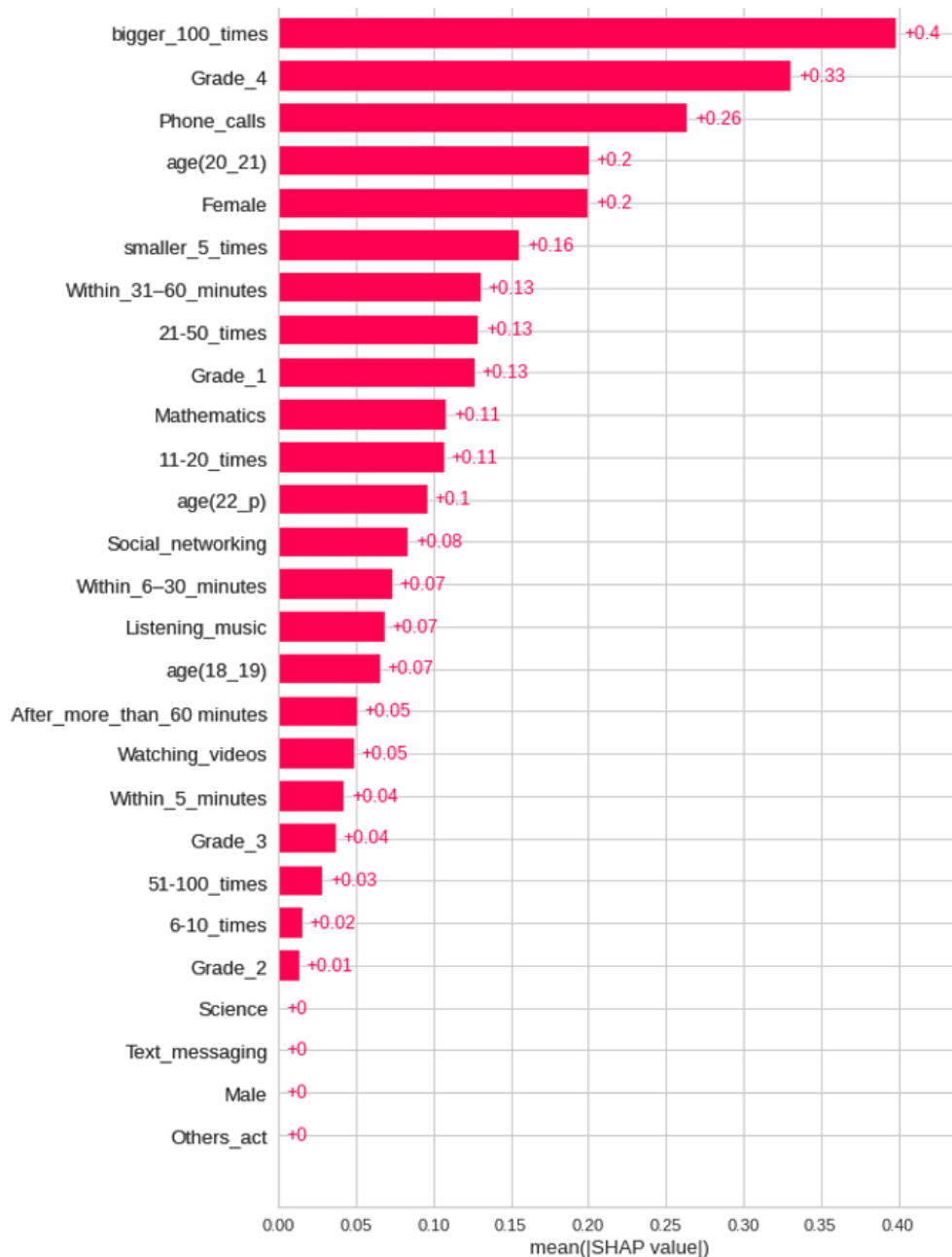
Figure 4. Mean F1-score for each feature for highest cluster and lowest cluster

Figure 4 (continued). Mean F1-score for each feature for highest cluster and lowest cluster

The effect of students' characteristics is seen in explaining students' highest level of addiction. While the most effective factor is that students use their phones for social media purposes; however, using other activities has no effect. Being male, using phones to call, listening to music, and sending text messages are seen as ineffective for explaining the highest addiction. The effect of students' characteristics is seen in explaining students' lowest level of addiction. While Using phone more than 100 times has more effective factor, age group has lowest effect. Most effective fact is usage frequency, grade, gender and usage functions.

For more detailed analysis, the chart of the feature level vs. each observation is examined (**Figure 5**). If participants use social networking and watching videos as relevant smartphone function positively high level. If participants use phone more than 100 times on a typical day has positive effect on smartphone addiction but 21-50 times and 6-10 times have negative effect. If participant use 50 times smaller, it decreases addiction level. While 3rd grade has negative effect, second grade has positive effect. Also, if the gender of participants is female, the addiction level is decreasing.
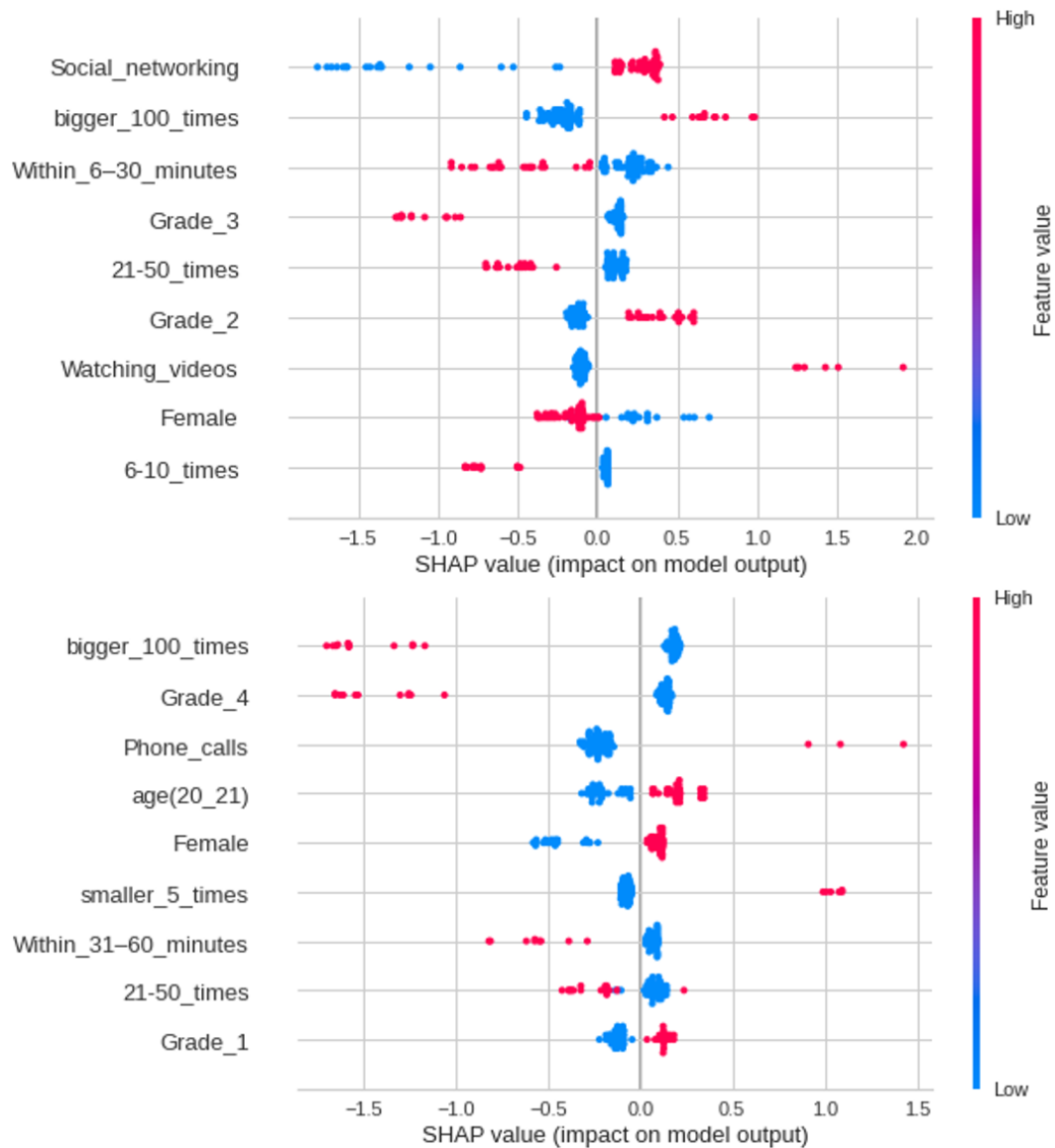
Figure 5. Contributions of SHapley values for highest (top) and lowest clusters (bottom)

For the lowest clusters, when the using phone more than times factor is examined, it is seen that red points are on the negative side. It means that if the student is using the phone more than 100 times, being lowest cluster decreases. Likewise, being in the 4th grade, using the phone to enter social networks, and being between 18-19 years of age also reduce being in the lowest cluster. But being female, first grade, using a phone to call, using a phone 6-10 times, and age over 22 increase being lowest clusters.

When we evaluate the common factors together, the fact that the participants use the phone more than 100 times increases their being in the highest cluster and decreases their being in the lowest cluster. Similarly, using the phone for social media is a factor that increases being in the highest cluster, while at the same time it decreases being in the lowest cluster. On the contrary, being female increases being in the lowest cluster, while it decreases being in the highest cluster.

DISCUSSION

The use of smartphones is high among pre-service teachers as well as in other areas of higher education (Abubakar Ismaila et al., 2019). The use of this excessive use at the level of addiction should also be examined. In this study, despite the low and high addiction levels in the groups, their general condition is moderate. The results of the study (Celik & Konan, 2019) also indicated that the preservice teachers in Turkey had moderate

levels smartphone addiction. However, according to another study's result pre-service teachers' addiction scores on smartphone use are lower than average. These results have the opposite. For example, according to Awofala's (2020) study, a sizable number of pre-service mathematics instructors in Nigeria demonstrated a high prevalence of smartphone addiction.

According to the findings, in the highest and lowest clusters, there is no change according to being male variable. But being female has an effect on whether you are in the highest or lowest cluster. Females have a negative correlation with the highest cluster, but a positive correlation with the lowest cluster. In contrast to the study, females were more susceptible to smartphone addiction than to internet addiction (Mok et al., 2014). Turkish female pre-service teachers reported feeling more secure, liberated, and excited when they used their cellphones, but they also reported feeling more impatient and frustrated when they did not have their smartphones in their hands (Gecgel, 2020). However, according to Konan et al. (2018) and Soomro et al. (2019), prospective teachers' levels of smartphone addiction do not differ significantly by gender. This result may be due to the fact that female prospective teachers use mobile phones less frequently. In a study by Abubakar Ismaila et al. (2019), it was concluded that female pre-service teachers used smartphones for learning less than their male counterparts.

The frequency and purpose of using mobile phones of the participants also affect their being in the highest and lowest clusters. For example, the use of mobile phones by pre-service teachers for social media increases the probability of being in the highest cluster. According to the SEM analysis conducted by Romero-Rodríguez et al. (2020), the positive and significant influence of the intensive use of Instagram on smartphone addiction. Similarly, communication and the usage of social media were significant predictors of smartphone addiction (Arnavut et al., 2018).

Despite the fact that it is underlined that determining what constitutes a high or low degree of SAI changes depending on the social setting (Lin et al., 2014). It has not been determined exactly at what level the use of smartphones is associated with smartphone addiction. According to the results of the research, using 100 times or more seems to have a critical value. In the findings, the use of 100 or more is positively associated with being in the highest cluster, while 21-50 and 6-10 uses are negatively associated. Conversely, when it comes to being in the lowest cluster, 100 or more uses are negatively associated, while 6-10 uses are positively associated. According to Harris et al. (2020), the frequency of smartphone use has been associated with smartphone addiction.

CONCLUSION AND RECOMMENDATIONS

In summary, despite the groups' low and high degrees of addiction, their overall state is moderate. The fact that you are female has an influence on whether you are in the highest or lowest cluster. Females correlate negatively with the highest cluster but positively with the lowest cluster. The frequency and purpose with which individuals use their mobile phones also have an effect on their placement in the highest and lowest clusters. Pre-service teachers' usage of mobile phones for social media purposes increases their likelihood of being in the highest cluster. The precise degree of smartphone use connected with smartphone addiction has not been discovered. Utilizing 100 or more times appears to have a critical significance. According to the results, usage of 100 or more is related to being in the highest cluster, whereas the use of 21-50 and 6-10 is connected with being in the lowest cluster. In comparison, being in the lowest cluster is adversely related with 100 or more uses, while being in the highest cluster is favorably associated with 6-10 uses.

Although many individuals have been using smartphones at a higher rate than usual due to the pandemic, reaching the point of addiction first impacts a person's mental and physical health. As a result, those who will be the future teachers must promote awareness among themselves and their pupils at the schools where they will work. Cluster analysis was performed in this study to determine low and high clusters using the k-means technique. Future researchers can investigate with other cluster analysis techniques. The purpose and frequency with which students utilize their time are determined by their own declarations. More objective measures may be made by assessing the length of students' use of the mobile application and the applications they use in conjunction with it.

As in every study, this study is not free of limitations. First, students' smartphone addiction was determined based on their self-reports and The SAI scale. Second, the fact that not all students in the relevant departments could be reached can be considered as a serious limitation. The inclusion of people with a very high level of addiction or, on the contrary, a very low level of addiction in sample will directly affect the results of the study. Third, there are limitations to methodological and analytical methods. Using different machine learning algorithms in cluster analysis and features determination studies may have an effect on the results.

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APPENDIX A

Inventory Smartphone Addiction

1. The overall socio-demographics contained questions regarding:
   a. What is your gender? .... [Male, Female, etc.]
   b. What is your age? ....
   c. What is major? .... [Mathematics, Science, etc.]
   d. What year are you in?
      i. Freshman
      ii. Sophomore
      iii. Junior
      iv. Senior

2. Questions regarding smartphone use:
   a. **Frequency of smartphone use on a typical day:**
      i. Less than 5 times/day
      ii. 6-10 times/day
      iii. 11-20 times/day
      iv. 21-50 times/day
      v. 51-100 times/day
      vi. More than 100 times/day

   b. **Time until first smartphone use in the morning:**
      i. Within 5 minutes
      ii. Within 6-30 minutes
      iii. Within 31-60 minutes
      iv. After more than 60 minutes

   c. **Most personally relevant smartphone function:**
      i. Social networking
      ii. Phone calls
      iii. Gaming
      iv. Text messaging
      v. E-mailing
      vi. Watching videos
      vii. Listening to music
      viii. Reading news
      ix. Other

3. Visual analogue scale (VAS):
   A1. How much does smartphone usage disrupt your everyday life?
   (0: Not at all; ...; 100: Very severely)
   A2. How much are you anticipating the usage of your smartphone?
   (0: Do not anticipate at all; ...; 100: Anticipating a lot)
   A3. How poorly are you feeling yourself when you cannot use your smartphone?
   (0: Not at all poorly; ...; 100: Very poorly)
   A4. How positively do you evaluate the relationships initiated through smartphone?
   (0: Very positive; ...; 100: Not at all positive)
   A5. How does the usage of your smartphone grow in time?
   (0: Does not grow at all; ...; 100: Grows very fast)

4. **Items of smartphone addiction inventory (English):**
   1. I was told more than once that I spent too much time on smartphone.
   2. I feel uneasy once I stop smartphone for a certain period of time.
   3. I find that I have been hooking on smartphone longer and longer.
   4. I feel restless and irritable when the smartphone is unavailable.

5. I have slept less than four hours due to using smartphone more than once.
6. I feel distressed or down once I cease using smartphone for a certain period of time.
7. I fail to control the impulse to use smartphone.
8. I feel aches and soreness in the back or eye discomforts due to excessive smartphone use.
9. I feel missing something after stopping smartphone for a certain period of time.
10. My recreational activities are reduced due to smartphone use.
11. I make it a habit to use smartphone and the sleep quality and total sleep time decreased.
12. I need to spend increasing amount of time on smartphone to achieve same satisfaction as before.
13. I cannot have meal without smartphone use.
14. I feel tired on daytime due to late-night use of smartphone.

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