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Digital distraction in the EFL classroom: How attention and self-regulation mediate learning outcomes

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Abstract

The widespread adoption of mobile devices in the context of higher education is associated with concerns about their potential effect on learners' attention and cognitive processing. This research aims to explore the influence of digital device use on students' performance in English as a Foreign Language (EFL), focusing specifically on the role of attention and self-regulation in mediating this relationship. A quasi-experimental pre-test–post-test control group design consisting of two conditions was adopted. The study included 50 EFL students enrolled at a private university who belonged to two intact classes assigned to either the control condition (digital device use restriction) or the experimental condition (unrestricted device use). Data collection entailed pre-tests, post-tests and delayed post-tests, questionnaires, and classroom observation. ANCOVA demonstrated a statistically significant difference in performance scores between these groups, with a large effect size. Moreover, repeated-measures showed the presence of low and inconsistent attention levels in experimental participants. Mediation analysis identified self-regulation as a variable that mediates the link between digital device use and academic performance. The findings indicated a tendency toward off-task activities and difficulties with sustaining attention. The current research shows that unrestricted use of mobile devices leads to poor attention and negative performance, which may have implications for classroom practices, digital learning policies, and strategies that encourage more effective self-regulated learning among EFL students.

Introduction

In recent years, rapid advancements in digital technologies have changed significantly the nature of higher education. One example of such change is related to the prevalence of mobile devices used by college students. Once limited in functionality solely to basic communication, mobile phones have become multifunctional communication and information devices offering continuous internet access, instant messaging capabilities, and various social networking services (Ishii, 2006; boyd & Ellison, 2008). For the majority of students, smartphones play an important role in everyday activities, providing both educational and social value. As a result, mobile devices have started to be actively used in the learning environment, including the classroom where attention and cognitive functions play a key role in effective learning. Although the use of technology can facilitate the exchange of information and communication, its presence in classrooms presents an ongoing challenge for both teachers and researchers. A major issue in this regard involves media multitasking in the context of simultaneous performance of various digital activities by students in addition to the completion of academic tasks (Junco, 2012; Hwang et al., 2014). Despite the fact that students typically consider multitasking beneficial or even efficient, numerous studies point out the possibility of its negative effect on students' learning due to attention distraction and cognitive load (Lin et al., 2015). These issues are primarily grounded in theories of information processing that consider learning as an activity that requires significant attention and working memory capacity (Mayer, 1996). The presence of various types of media stimuli, besides instructional content, reduces information encoding efficiency, potentially leading to poor comprehension and memorisation. Moreover, the process of multitasking negatively impacts self-control, making students unable to properly pay attention and avoid distractions (Wei et al., 2012). There is ample evidence showing that the use of digital devices in classrooms negatively affects academic success and comprehension, measured with the help of exam results and note-taking quality (Kuznekoff & Titsworth, 2013; Wood et al., 2012). Most of these findings were obtained using the correlational designs that did not allow establishing causality. Furthermore, most of these studies focused on specific outcomes, such as grades. Therefore, further research is needed to explore how mobile technology distracts students' attention during class and how this phenomenon influences their learning processes.

This research aims to fill this gap by examining the effect of mobile technology use on English language learning among university students focusing specifically on attention, self-regulation, and academic success. The proposed study will include the comparison of two conditions – the device-free classroom and regular classroom with unlimited mobile device use. Using a quasi-experimental research design, the study aimed to examine associations between variables and provide insights into the mechanisms underlying media distractions in the learning environment.

Literature Review

The rapid spread of mobile technology among young people and its incorporation into the daily lives of students has attracted considerable scholarly attention to its roles in education-related situations. Once limited to voice communication, modern mobile phones have become multifunctional devices that allow users to access the Internet, exchange text messages, and interact with others via social network sites (SNS). SNS are defined as online environments that enable users to build personal profiles, connect with others, and communicate in existing social networks (boyd & Ellison, 2008). This trend has significantly changed the way young adults communicate, especially university students who are highly engaged with such platforms during the day. Empirical data clearly show that mobile phones are widely used by students. A significant proportion of young adults are regular senders and receivers of text messages and internet users via their mobile phones (Zickuhr, 2011). Adolescents report frequent texting and admit sending text messages during classes (Lenhart, 2010; Lenhart et al., 2010; Ransford, 2009). In addition, it is widely accepted that most adolescents and young adults actively use SNS and communicate with their peers on a daily basis (Lenhart, 2009, 2010). Hence, mobile communication not only prevails in young people's daily routine but also reaches formal educational settings.

Attitude-based studies indicate that younger people perceive mobile phones as an instrument to maintain contact with friends and family members and are willing to accept their use in class. However, the increasing reliance on mobile technology has raised concerns among teachers about possible distractions in the learning environment. Some educators limit the use of mobile phones in class because they believe that their use can hinder the learning process (Steinfatt, 2009). Indeed, various theories and empirical studies have demonstrated that multitasking with mobile devices might distract students' attention and hamper cognitive processes that underlie effective learning.

Explanation of Potential Negative Effect of Mobile Phone Use

According to information processing theory, learning is a process of information acquisition that consists of three stages – attention, working memory, and long-term memory (Mayer, 1996). In order for students to learn new material during lectures, it is necessary to maintain their attention and encode information properly into memory. When multitasking with mobile devices during lectures, students distribute their attention between educational activities and mobile phones, thus fragmenting cognitive resources needed to attend to information and encode it in memory. Studies on driving while using mobile phones corroborate this explanation by revealing that performing cognitively complex activities, such as having a conversation or sending text messages, distracts drivers' attention and hinders

successful task completion (Harbluk et al., 2007; Just et al., 2008; Trbovich & Harbluk, 2003). Although the impact of mobile devices during lectures is less harmful, similar cognitive mechanisms could work when students engage in mobile phone use during lessons.

There is also extensive empirical evidence that digital multitasking during lectures hampers academic performance. For example, Kraushaar and Novak (2010) revealed that the majority of students' laptop activities was irrelevant to course material and negatively correlated with academic success. Similarly, Wood et al. (2012) showed that multitasking with technologies such as texting, emailing, and social networking sites resulted in low exam scores. Wei et al. (2012) found texting to be a factor that diminishes students' self-regulation abilities, which are crucial for paying attention to lectures and achieving cognitive learning goals. Altogether, these studies demonstrate that mobile phone use during lectures hampers the learning process by distracting students' attention. Previous research has extensively investigated the link between mobile phone use and learning outcomes, but little attention has been paid to the mechanisms that drive this association. The current research aims to address this gap by exploring the role of attention and self-regulation as mediators of digital device use in the context of learning. In particular, the study focuses on the association between mobile phone use and note-taking as an indicator of attention and learning outcomes.

Role of Note-Taking in Learning

Taking notes is known to be a vital component of efficient learning (Mayer, 1996). Not only is note-taking a widely used practice in schools and universities, but it is also a powerful tool to improve comprehension and retain information in memory. Kobayashi's meta-analysis (2006) reveals that exam results of students who make notes and later revise them are significantly higher compared to students who did not take notes. In addition, it was discovered that the organization of notes plays a crucial role, as structured and thorough notes are positively associated with improved understanding of information (Makany et al., 2009). These results indicate that note-taking is important for learning. The importance of taking notes is discussed within the scope of two theoretical frameworks – encoding hypothesis and external storage hypothesis. Encoding hypothesis assumes that note-taking promotes cognitive processing and, hence, facilitates learning (Rickards, 1979). External storage hypothesis, on the contrary, suggests that notes are an additional storage source that helps learners retrieve information (Kiewra, 1987). Encoding and external storage hypotheses operate concurrently to facilitate learning (Kiewra et al., 1991). Any interference in note-taking process will negatively affect learning. Moreover, note-taking is a complex and cognitively demanding task. To take good notes, a student must first listen carefully to the lecture, recognise important points, and comprehend information, and then record relevant information in written form (Kiewra, 1987). This process becomes even more complicated in case of

distracting activities that compete for a learner's attention. Empirical studies show that only a small fraction of information presented in lectures is recorded by students (Boyle, 2011; Kiewra, 1985; Titsworth & Kiewra, 2004). Hence, note-taking is a limited and selective process. Using a mobile phone during lectures might undermine the quality of notes.

It is reasonable to assume that mobile phone use during lectures can impair learning in several ways. First, it hampers the attention process and decreases cognitive resources allocated to information processing during lectures (Mayer, 1996). Second, it interferes with the process of note-taking and negatively affects the encoding and external storage processes (Kiewra, 1987; Rickards, 1979). Finally, it reduces the self-regulation level, making it harder for students to maintain their attention on academic tasks (Wei et al., 2012). All these factors will contribute to decreased learning outcomes. Furthermore, it should be mentioned that texting and SNS communication might differ in the degree of attention needed for communication but can be viewed as similar types of mobile-mediated distractions. Even though they fulfil distinct social functions, these practices require active participation in mobile-mediated communication and, hence, distract attention from instructional information. Therefore, they can be regarded as mobile-mediated distractions that have similar effects on attention.

Media Multitasking and Academic Performance

Multitasking with two or more media has become the primary behavioural pattern of modern university students, who spend much time interacting with different digital devices during the day (May & Elder, 2018). There is ample evidence that media multitasking is widespread among students and occurs not only during lectures but also when completing homework and reading (Hwang et al., 2014; Judd, 2014; Junco, 2012). Despite students' beliefs that multitasking improves their productivity, empirical studies reveal the opposite – media multitasking is consistently associated with poor academic performance (Lin et al., 2015). From a theoretical perspective, media multitasking affects learning outcomes due to information processing theory and attentional models. According to information processing theory, attention is defined as a cognitive resource that is limited. When performing multiple tasks simultaneously, individuals have to divide and switch attention between competing streams of information, resulting in cognitive overload (Broadbent, 1958; Maslovat et al., 2013; van der Schuur et al., 2015). Another concept, the bottleneck theory, suggests that only one stream of information can be processed at a time, which leads to delays when performing multiple tasks (Broadbent, 1958). Scattered attention hypothesis implies that frequent multitasking disrupts attentional control, making it hard for students to concentrate on goal-relevant information (van der Schuur et al., 2015). Although trained attention hypothesis argues that multitasking increases cognitive flexibility, empirical data shows that frequent multitasking deteriorates cognitive performance (Courage et al., 2015; Ophir et al., 2009).

Working memory theories explain that multitasking affects cognitive performance as working memory is a resource that has limited capacity and plays an important role in learning. Individuals who frequently multitask have worse working memory performance and, thus, cannot effectively manage cognitive load (Cain et al., 2016; Redick, 2016). Empirical data consistently demonstrate that multitasking is associated with poor academic results. Heavy users of digital media usually have low grade point averages (GPAs) and academic performance (Roberts et al., 2010). Surveys and longitudinal studies confirm that multitasking is negatively related to GPA and academic achievement (Al-Menayes, 2015; Bellur et al., 2015; Clayson & Haley, 2012; Junco, 2012; Lau, 2017; Walsh et al., 2013). Thus, multitasking behaviours can cumulatively affect academic performance. Multitasking behaviours are detrimental to learning outcomes during lectures. Students who text or engage in other off-task behaviours during class have lower exam results than attentive students (Ellis et al., 2010; Froese et al., 2010; Rosen et al., 2011). Also, multitasking adversely impacts note-taking, as distracted students write down less information and retain it poorly (Kuznekoff & Titsworth, 2013). The nature of multitasking is also crucial, as off-task activities (such as texting) are more disruptive than on-task use (Kuznekoff et al., 2015). Multitasking using laptops and other digital devices during lectures has a negative effect on comprehension, memory, and academic success (Fried, 2008; Hembrooke & Gay, 2003; Kraushaar & Novak, 2010; Sana et al., 2013; Wood et al., 2012). More importantly, multitasking has a negative effect not only on the learner but also on adjacent students, who suffer from reduced learning due to distraction (Sana et al., 2013). Outside the lecture hall, media multitasking during studying also impedes learning processes. Students who send text messages or use SNS while studying tend to have lower GPAs and poor academic performance (Junco, 2012; Junco & Cotton, 2012; Karpinski et al., 2013; Lepp et al., 2015). Multitasking also decreases the efficiency of learning process, as students require more time to complete tasks when switching between activities (Bellur et al., 2015; Bowman et al., 2010; Fox et al., 2009). Although some researchers argue that comprehension is maintained through compensatory measures like re-reading, this takes place at the cost of efficiency (Bowman et al., 2010; Pashler et al., 2013).

Another aspect of media multitasking that deserves consideration is students' attitude towards the behaviour and self-regulation skills. Several studies found that students realise the negative effects of multitasking on learning outcomes; however, they underestimate the risks and overestimate their abilities to multitask successfully (Ravizza et al., 2014; Kraushaar & Novak, 2010; Clayson & Haley, 2012). Moreover, students' self-regulation level moderates the negative effects of media multitasking, as individuals with better self-regulation are less likely to perform off-task behaviours during lectures and concentrate better during learning activities (Wei et al., 2012).

Thus, empirical evidence strongly suggests that media multitasking negatively influences academic performance, as it hampers attention, working memory, comprehension, note-taking, and efficiency.

Multitasking has adverse effects on learning during lectures and when studying independently, although it is driven by information processing theory and attentional models. On the other hand, students' attitudes toward multitasking and self-regulation abilities moderate its effects. Based on the reviewed literature, there is a necessity to investigate the mechanisms underlying the relationship between mobile phone use and learning outcomes. In particular, there is a need to explore the extent to which mobile phone use affects students' note-taking behaviours during lectures. This study aims to answer the following research questions.

Research questions

Q1: To what extent does unrestricted digital device use during classroom instruction affect EFL students' language learning performance compared to a device-restricted environment?
Q2: How do attention and self-regulation mediate the relationship between digital device use and EFL students' learning performance?

Methodology

Design of the research

The current study adopted an embedded mixed-method quasi-experimental pre-test–post-test control group design with a delayed post-test to examine changes over time. This approach allowed for the examination of the impact of unrestricted use of digital devices in the learning context on students' attention and English language performance over time. The control and experimental conditions involved two intact classes assigned to either condition at the class level. Baseline equivalence between groups was evaluated statistically using pre-test comparisons. Specifically, in the experimental condition, students could use digital devices freely during learning tasks, while in the control condition, use of these devices was discouraged during classes. Moreover, the same instructor delivered lessons to both groups using identical instructional materials for six weeks.

Participants and variables

The current study involved 50 participants who were undergraduate students of the foundation English courses at a private university in Istanbul. Specifically, these foundation courses aimed to enhance students' English proficiency and prepare them to study in English-medium programs. The participants belonged to two intact foundation English classes, with one class assigned to the control group (n = 25) and the other assigned to the experimental group (n = 25). All participants admitted using digital devices intensively on a daily basis for both social and educational purposes. An independent-samples t-

test revealed there were no significant differences in English language skills among the groups at the baseline phase ($p > .05$). Participants represented various disciplines, making it a representative sample of EFL learners in private HEIs in Turkey. As the independent variable, the researcher employed the level of digital device use, which was defined in the study as restricted and unrestricted use. The dependent variables included attention, which was further subdivided into behavioural indicators (focusing on off- vs. on-task behaviour) and subjective experience; as well as English language performance in terms of reading comprehension, vocabulary knowledge, and writing accuracy. Self-regulation was used as the mediating variable, reflecting the ability of learners to manage attention, control distraction, and focus on learning tasks.

Instruments

Multiple instruments were employed to collect and measure data comprehensively. Specifically, a pre-test, post-test, and delayed post-test were used to measure the reading comprehension, vocabulary knowledge, and writing accuracy of participants in terms of English language skills. The parallel forms were applied to prevent potential testing effects. Content validity of the tests was confirmed by a panel of EFL experts, and the reliability coefficient exceeded .80 (Cronbach's alpha). A Likert-scale questionnaire was administered to measure subjective levels of attention of participants, as well as distractibility associated with multitasking behaviour and other aspects of attention management. Prior to the experiment, the questionnaire was tested and proved to be reliable ($\alpha = .87$). To measure self-regulation in terms of attention, effort, and persistence, an adapted MSLQ was used. Behavioural measures included systematic observations of classroom activities of students, which were conducted via a checklist in five-minute time frames. Inter-rater reliability was estimated based on the coefficient Kappa and found to exceed 0.75.

Procedure

The study lasted nine weeks and included four phases: baseline assessment (Week 1), intervention (Weeks 2–7), immediate post-test assessment (Week 8), and delayed retention assessment (Week 9). baseline testing, intervention period, immediate post-intervention assessment, and delayed retention assessment. Ethical clearance was acquired from the relevant institutional committee, and informed consent from all participants was obtained prior to the start of the study. It was assured to participants that participation was purely voluntary, and they had the right to withdraw from the study at any point without incurring any academic penalties. All data gathered were going to be strictly confidential and used exclusively for the purpose of the study.

In Week 1, all participants underwent baseline testing during standardised test sessions. In order to evaluate their English language abilities, attention skills, and self-regulation capabilities, participants

took English language pre-tests, filled out an attention questionnaire, and self-reported self-regulation. The testing procedure, including the instructions, the duration of assessments, and the setting, remained standard across both groups. To assess the baseline equivalence of groups before treatment was begun, statistical comparison was carried out. The six-week-long intervention period started after the initial assessment. During the treatment, both groups were provided with equal amount of instructional time and identical instructional material; therefore, both groups learned the same material and were expected to reach the same learning goals during this period. In addition, both groups met equally often and studied equally long (one hour of lessons each day) and learned the same material. The instructor for both classes was the same in order to minimise variability introduced due to different teaching styles. During the control group treatment, learners were engaged in English language classes in a digitally restricted environment. Specifically, students were discouraged from using mobile phones, tablets, laptops, or any other kind of digital device unless they were specifically required by the instructor during the class time. Classroom activities relied on face-to-face interaction, instruction of the instructor, and learning activity engagement. Periodic checks for compliance with restriction were regularly conducted.

As for the experimental group, learners were allowed to use their digital devices freely during classroom activities, for both academic and non-academic purposes. Students had no device restrictions while they worked on typical classroom assignments. By removing such restrictions, it was possible to replicate real-life patterns of technology use. Moreover, in cases when it was necessary to manage the classroom, instructor did not intervene with learner-device usage. Behavioural observation was used to monitor learners' level of attention and engagement during the treatment period. Structured classroom observation involving use of a checklist was conducted twice per week; observers registered presence of certain indicators (indicated by 'on' or 'off') every five minutes according to predetermined guidelines. Attention-monitoring activities were also routinely administered to observe changes in attention and engagement. Observations followed predetermined guidelines and were accompanied by inter-rater reliability procedures. Upon completion of the intervention period, in Week 8, all participants took immediate post-tests to evaluate how much progress they made during the previous weeks. Language post-tests were parallel to pretests, and attention self-report questionnaires and self-regulation scales were completed again. Administration procedure was maintained identical for both conditions. A delayed posttest was given in Week 9 as an assessment of learners' ability to retain what they have learned in the classroom over time. By giving delayed measurements, it was possible to investigate if any previously detected differences in English language performance persisted after the completion of the training period.

Data analysis

SPSS was used to analyse quantitative data. Measures of central tendency, such as means and standard deviations, were employed to summarise data. Independent-samples t-tests were used to examine baseline equivalence between groups on pre-test measures. Differences in language learning outcomes were evaluated using analysis of covariance (ANCOVA) with pre-test scores as a covariate. Prior to conducting ANCOVA, assumptions of normality, homogeneity of variance, linearity, and homogeneity of regression slopes were examined. Changes over time in attention were assessed using repeated measures analysis of variance. Effect sizes (Cohen's d, eta squared) were calculated to evaluate the significance of the findings. Moreover, mediation analysis was conducted to evaluate if self-regulation mediated the influence of digital device use on language learning.

Validity and trustworthiness

To enhance the rigour and credibility of the study, several approaches were used. Specifically, baseline equivalence, control of instructional variables, as well as the application of ANCOVA helped to establish internal validity. Conducting the study in a real classroom setting increased ecological validity; however, the use of a single institution and a small sample limits broader generalisation. Reliability was achieved due to the application of already validated and reliable instruments with $\alpha \geq .80$. Moreover, for observational data, high inter-rater reliability ($\kappa \geq .75$) was achieved.

Ethical considerations

An ethical approval was sought from the university research ethics committee prior to collecting the data. All participants provided their informed consent and agreed to participate in the study, having been explained its aims and procedures. Confidentiality and anonymity were maintained via coding of all data. Participation was completely voluntary, and no adverse consequences for participants were imposed if they refused or decided to leave the experiment.

Preliminary analysis

The first step before conducting the analysis was performing an independent-samples t-test to test whether there was any significant difference between the control group and the experimental group in terms of pre-test scores. The result indicated that there was no significant difference between the two groups ($p > .05$).

Effects of digital device use on language performance

In order to evaluate the effect of digital device use on students' English language performance, an analysis of covariance (ANCOVA) was carried out, where the score in the post-test was considered the dependent variable, the type of group (control or experimental) as the independent variable, and the score in the pre-test as the covariate (Table 1). The findings revealed that the model fitted well statistically, $F(2, 47) = 173.63$, $p < .001$, indicating high significance. The proportion of total variance that could be predicted by the model was considerable at $R^2 = .881$ (adjusted $R^2 = .876$).

Table 1
Tests of Between-Subjects Effects

Dependent Variable: Post_test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1374.033[a]	2	687.017	173.632	.000
Intercept	5.868	1	5.868	1.483	.229
Pre_test	1025.553	1	1025.553	259.191	.000
Group	405.320	1	405.320	102.438	.000
Error	185.967	47	3.957		
Total	245162.000	50			
Corrected Total	1560.000	49			

a. R Squared = .881 (Adjusted R Squared = .876)

Pre-test scores turned out to be a covariate which was statistically significant, $F(1, 47) = 259.19$, $p < .001$. Hence, initial proficiency levels of participants significantly impacted their performance on post-tests. Thus, the usage of pre-test scores as a covariate is justified, as well as ANCOVA adjustment for differences between the groups at the pretest level. Also, the main effect of the group on post-test scores proved to be statistically significant, $F(1, 47) = 102.44$, $p < .001$. The results suggest that, having adjusted for pre-test scores, a statistically significant difference in language performance exists between experimental and control conditions. Moreover, the effect size was high (partial $\eta^2 = .69$). This suggests that a large practical difference existed between two groups. As regards mediation, self-regulation turned out to be one of mediators between digital device usage and language performance.

Interpretation of group differences

The significant group effect suggests that the extent to which the participants had access to the digital devices had an influence on their learning results. Taking into account the fact that there was no significant difference between the two groups at the pre-test stage, students who were deprived of access to the devices scored more on the post-test than those who had unrestricted access to the devices.

Discussion

The present paper presents strong evidence suggesting that unrestricted usage of smartphones or other gadgets interferes with language acquisition in the class, resulting in decreased attention capacity and inefficient engagement during learning. Moreover, the present findings confirm existing theoretical perspectives concerning the negative influence of mobile-mediated multitasking on cognitive processes needed for effective learning and extend prior empirical results by discussing specific mechanisms underlying these adverse outcomes. One of the main findings of the study concerns the between-groups' performance in a post-test after the adjustment for participants' initial proficiency levels. It is clear that those students who had unrestricted access to their digital devices performed considerably worse than those with limited access to smartphones and gadgets. Such a large effect is quite informative concerning the power of digital devices to negatively affect language acquisition and suggests that the presence of smartphones during instruction can be viewed as a meaningful factor in the process of EFL learning. At the same time, one should note that the magnitude of the present findings is higher compared to typical effects in correlational designs. As a rule, correlational studies in language acquisition find moderate positive correlation between smartphone usage and poor learning outcomes. As such, one should pay much attention to the fact that the current study employed a quasi-experimental design, which allows stronger examination of associations than correlational methods, although causal interpretations should remain cautious.

These conclusions seem to be consistent with information processing theory emphasising the limited capacity of attention and working memory in language learning (Mayer, 1996). Indeed, engagement in multitasking during class decreases the possibility for deep processing of information provided by an instructor and prevents proper encoding of linguistic material. The present study confirms these assumptions since poor performance in the experimental group can be attributed to poor attention management during the class, as well as to insufficient information processing. It seems reasonable to conclude that multitasking can be considered not only an undesirable activity but also a cognitive constraint interfering with the process of learning. However, these adverse effects can also be explained by the nature of the used devices since smartphones tend to provide users with numerous distractors leading to reduced concentration. Overall, such interference with cognitive processes necessary for proper

learning seems to explain negative effects of mobile-mediated multitasking on learning outcomes and performance.

One should note that the above-mentioned findings can be supported by the observation that digital distractions do not occur spontaneously. On the contrary, they are caused by learners' inability to properly attend to the information and concentrate on learning materials. This problem was discussed earlier and proved to be especially severe for the process of language acquisition (Kuznekoff & Titsworth, 2013; Rosen et al., 2011). However, prior studies were focused primarily on frequency of such events without analysing their nature in real-life classroom settings. The present study has provided sufficient evidence in favour of such an approach.

More specifically, it is clear that the present study confirmed the hypothesis about the importance of time as a dimension of attention and distractedness. Indeed, repeated-measure designs showed that attention levels in the experimental group do not stabilise but rather fluctuate and eventually fall. Hence, it can be assumed that mobile distractions constitute an ongoing process that gradually develops throughout the whole lesson. The accumulated impact of such distractions can lead to substantial learning disadvantages even when learners use digital devices occasionally or for short periods of time.

It seems that the described phenomenon can be explained using the concept of scattered attention (van der Schuur et al., 2015). Indeed, the frequent task-switching leads to insufficient attentional allocation during language instruction. In turn, this process negatively affects language skills of students and reduces their performance, which can explain the significant difference between experimental and control groups. Hence, the current findings are important in terms of confirming and expanding theoretical knowledge on the topic. It is also important to pay special attention to the role of self-regulation in the current discussion. More specifically, the analysis of the data collected during the experiment has shown that those students who had low self-regulation were significantly more vulnerable to digital distractions. These individuals showed higher levels of distractedness during the learning session, as well as poorer results in the final test. Overall, these findings correspond with those of Wei et al. (2012), who emphasised the importance of self-regulation in the process of learning. Hence, the current study provides additional evidence in favour of this hypothesis.

Importantly, the negative effects of digital devices cannot be generalised in terms of being inherent to all types of technology. Instead, these adverse effects are rather related to the peculiarities of individual self-regulation capacity and its efficiency. Therefore, the current findings shift the focus of the discussion from the problematic technology per se to its effective management within the classroom and proper teaching techniques aimed at developing metacognitive skills in students. Nevertheless, instructors should not expect learners to have efficient self-regulatory skills since prior research shows that students tend to overestimate their abilities to conduct multiple tasks simultaneously (Ravizza et al.,

2014). In turn, the present results show that the overwhelming majority of learners overestimated their possibilities to use devices productively during instruction. Most participants appeared to underestimate the negative influence of digital distraction on their learning performance; however, the findings suggested otherwise. Overall, it can be argued that the negative effects of digital distraction occurred regardless of students' perceptions of these activities. It is possible that note-taking was not affected significantly during the experiment because of the lack of measures of this kind. However, it seems highly unlikely since poor attention usually leads to lower efficiency in this activity (Kiewra et al., 1991). Therefore, it is safe to assume that note-taking in the experimental group was affected negatively, which explains the poor academic performance of these students. In turn, the delayed post-test results confirm the validity of these claims since there are no grounds to suggest that digital distractions would not interfere with the encoding and long-term retention of information.

The current findings show that the process of information encoding and storage in the experimental group was adversely affected during the class. In turn, this process negatively impacted performance in the delayed post-test, which proves that digital distraction affects not only short-term learning outcomes but also the durability of knowledge gained throughout instruction. As such, this temporal aspect provides important insights into the nature of negative effects. In terms of discussing previous research, it is necessary to state that the presented findings are fully consistent with the literature in the field. Specifically, the existing studies show a high level of negative association between media multitasking and learning results. The major novelty of the current study consists in the combination of qualitative and quantitative methods of assessment, as well as the implementation of the experiment in the context of actual classroom instruction (Junco, 2012; Lin et al., 2015). This allows for obtaining a better understanding of negative effects of digital distraction and their mechanisms. At the same time, one should not assume that all types of digital distraction are necessarily bad. Previous studies indicate that there are types of device usage that can positively affect learning and performance of students. For example, Kuznekoff et al. (2015) demonstrated that digital devices can serve a supportive role in classroom learning when used appropriately. In this case, the current research provides evidence of negative effects related to unrestricted access to phones and computers.

The presented results can also be discussed in pedagogical terms. First, it is important to pay special attention to the fact that the current findings are informative in terms of providing insights into the optimal strategies for managing digital distractions. As such, it is crucial to implement strict rules concerning the access to technology during instruction. At the same time, complete restriction of access can also have detrimental effects; thus, some solutions should be developed. For instance, the instructor should encourage task-oriented use of mobile devices during instruction. Moreover, special classroom tasks can be used to minimise the risks associated with distractions and promote better learning. Overall, instructors need to pay special attention to this area, and appropriate practices should be developed.

In addition, self-regulation should be promoted among students to enable efficient learning and minimise the risks of distractions.

Limitations

Although the current research makes several important contributions to the existing literature, there are several aspects that should be addressed in the future. First, one should point out that the present research was based on a rather small sample taken from a single university. Such a sample does not allow generalising the obtained results and requires the inclusion of broader groups of learners in the study. Second, the use of intact classes rather than individual random assignment limits causal inference and may have introduced pre-existing group differences. Finally, one should mention the limited duration of the conducted intervention. Overall, these issues can be addressed through future studies with larger samples, randomised assignments, and longitudinal designs.

Conclusion

This research analysed the effects of digital device usage on students' performance during learning, paying special attention to attention and self-regulation. Based on the conducted experiment, it can be concluded that unrestricted digital distractions lead to reduced learning performance, decreased attention levels, and enhanced vulnerability to distractions during instruction. It is interesting that the present results confirm the previously stated assumptions about negative effects of mobile distractions on language acquisition but also provide additional insight into mechanisms underlying these phenomena. In particular, it can be concluded that digital distraction involves complex cognitive processes, such as scattered attention, impaired self-regulation, and poor focus on information provided by an instructor. In addition, one should not ignore the importance of temporal factors affecting the process of distractedness and learning. Namely, this paper demonstrates that digital distractions reduce the quality of information processing and decrease the likelihood of effective encoding, which affects performance in delayed tests. The present study provides some grounds for rejecting unrestricted usage of smartphones in the class, although it cannot serve as a rationale for exclusion of digital technologies from the instruction. Instead, one should strive for implementing digital distraction minimising strategies within the educational process.

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Conflict of interest

The researcher confirms that there is no conflict of interest associated with this study.

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