Effects of Mobile Devices Usage on Students' Learning Success at Vocational Colleges

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Abstract

The COVID-19 pandemic can be regarded as a significant catalyst for the digitalisation of school education. The widespread availability of mobile devices, combined with the emergency pandemic-conditions, fostered a greater acceptance of their use for educational purposes among both teachers and students. As there has been no apparent decline in the use of digital technologies since the end of the pandemic, a closer examination of mobile devices from an educational research perspective appears warranted. Notably, existing literature has paid limited attention to the temporal dimension of mobile device usage in educational contexts. Furthermore, a research gap has been identified with regard to vocational schools offering economics-related subjects. Against this background, the present study investigates whether the integration of mobile devices can enhance students' learning outcomes, and how the timing of their use specifically influences learning success. For data collection, both analogue and digital tests are administered within homogeneous educational programmes, allowing for meaningful comparison. The study involves a total of 243 students across 16 classes. These are evaluated at different points in time—at the beginning or the end of the lesson—to measure differences in performance. Overall, the findings indicate that the use of mobile devices, in and of itself, does not significantly enhance learning outcomes. Similarly, the timing of device use does not yield measurable differences in performance. Instead, the results underscore the importance of purposeful and pedagogically integrated use of mobile technologies within the learning process to achieve meaningful educational benefits.

Keywords: mobile devices, learning success, vocational education, didactic of economics

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Introduction

For about a decade, scientific research has increasingly focused on the influence of mobile devices such as smartphones and tablets on academic success (Heinen et al., 2013; Macgilchrist et al., 2023; Müller et al., 2018). Numerous studies highlight positive aspects, such as increased motivation through the use of mobile devices as a learning aid (Hillmayr et al., 2017, p. 19; Pichler, 2021; Scharpf & Gabes, 2022; Yamamoto, 2013), as well as the special support provided to lower-performing students through individualised teaching using smartphones and tablets in the classroom (Galley & Mayrberger, 2018, p. 50f). Other studies point to possible disadvantages of use, such as Lepp, Barkley & Karpinski (2014), who show in their study that multitasking and increased distraction can have potentially negative effects on academic success. Technical challenges, as highlighted by Gikas and Grant (2013), and data protection concerns (Galley & Mayrberger, 2018, p. 50) can also pose obstacles to the use of mobile devices.

State of Research

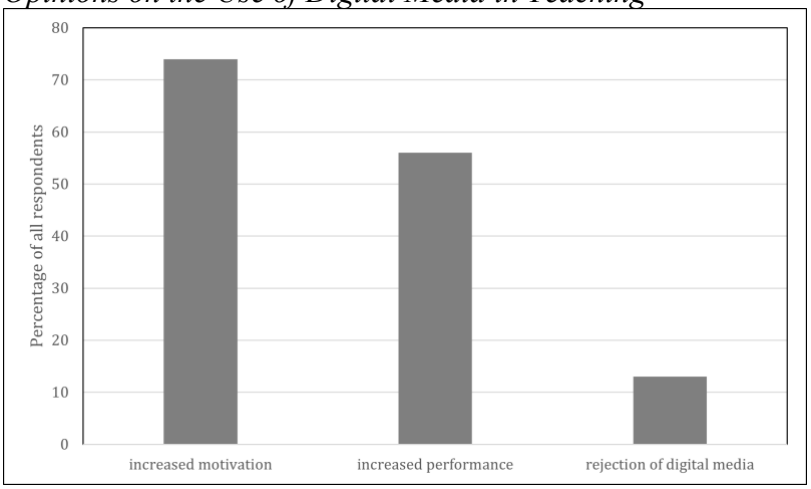
With the increased use of digital media in schools, especially since the beginning of the COVID-19 pandemic, the landscape of school learning has changed fundamentally. A survey conducted after the first phase of COVID-19 school closures found that a quarter of respondents reported experiencing more intensive learning activity as a result of the increased use of digital media (Huber et al., 2020, p. 23). COVID-19 caused the use of mobile devices in school learning to rise from 66% to 96% (Initiative D21 & TU Munich 2020, p. 3). Current data from the JIM study show that 52% of 18- to 19-year-olds regularly use smartphones and 47% use tablets in class (mpfs 2023, p. 58).

However, students use their smartphones not only for school purposes, but also for personal matters such as writing messages or looking up answers during exams. This leads to the challenge that the ability to learn can be disrupted by this diverse use (Synnott 2017, p. 162). O'Bannon and Thomas (2015) list barriers and difficulties that can be associated with smartphones in the classroom, including classroom disruption and learning barriers. According to Hattie (2009, p. 37), students should be able to achieve effective learning success through control over the learning process. Flexibility in mobile devices, temporal and spatial availability, control options and functions of these devices play a decisive role here.

From the students' perspective, the use of digital media in the classroom also seems to confirm these statements. According to a study by BITKOM (2023, p. 5), 74% of the 504 participants surveyed believe that the use of digital media in the classroom increases their motivation. Similarly, 56% believe that this leads to better grades. However, there is also a small minority (13%) who tend to reject digital media in the classroom. This concerns can be attributed in part to the potential for distraction and the growing desire for screen-free time (Friedrichs-Liesenkötter & Karsch, 2018). The opinions on the use of digital media in the classroom are shown in Figure 1.

Figure 1

Opinions on the Use of Digital Media in Teaching



According to Schmid (2022, pp. 165–168), students' attention span is highest in the first 20 minutes of a lesson. Attention span depends on a number of factors, such as interest and fatigue-related physiological conditions (Niegemann & Weinberger, 2020, pp. 139–140).

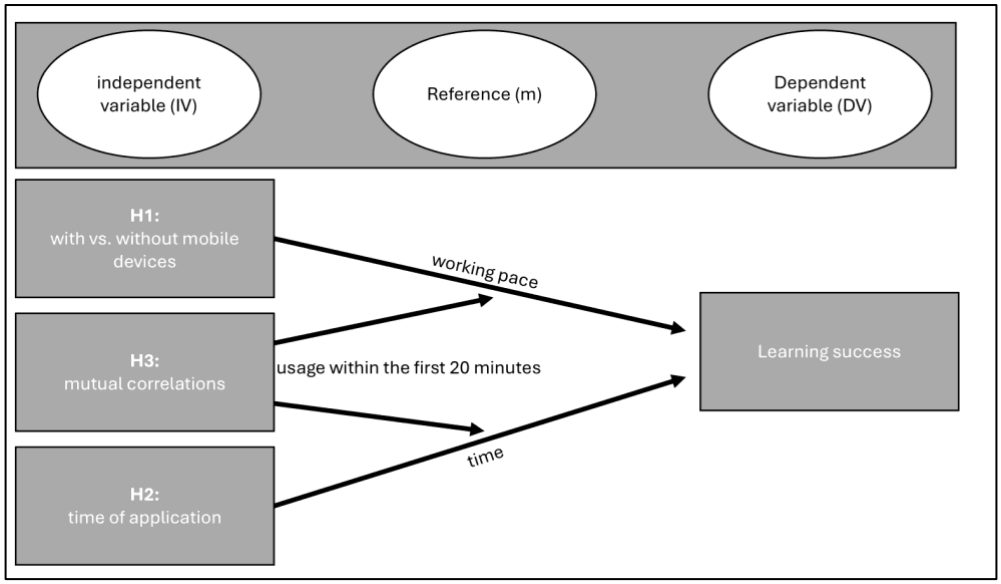
Current research largely focuses on the use of mobile devices in lessons at general education schools. Despite numerous studies on the effects of mobile devices in a school context, there is still a research gap regarding their use at vocational colleges in economics subjects. The analysis of the timing of mobile device use in the classroom also points to a lack of knowledge. The existing literature does not provide comprehensive information on how the timing of mobile device use influences learning success in vocational colleges offering economics subjects.

The combination of a lack of specific research for vocational colleges with an economics focus and the unexplored dimension of the timing of the use of mobile devices in the classroom represents a key research gap. Considering this gap is essential in the context of an increasingly digitalised world and the associated integration of technology in educational institutions. It can provide valuable insights into how mobile devices can be meaningfully integrated into teaching to promote the learning process.

Given these circumstances, there is a need for targeted research to explore the specific effects of mobile device use in vocational colleges in economics subjects and to understand the importance of the timing of use for learning success.

Figure 2

Research Model: Effects of Mobile Devices on the Learning Success of Students in Vocational Schools

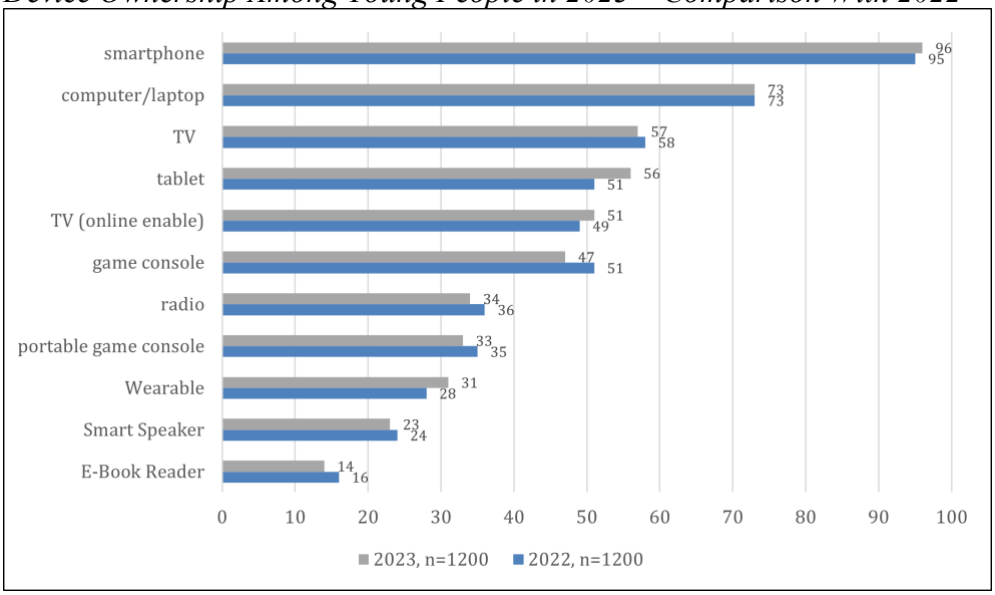


The use of mobile devices enables learners to study flexibly and independently of location and promotes self-regulated and self-directed learning (Aufenanger, 2020, p. 31). Mobile devices offer a wide range of possible applications in the classroom, as they have microphones and cameras and also enable collaborative work on learning content (cf. ibid., pp. 29–30). These functions support various types of coding – such as visual and auditory elements or symbolic and pictorial representations – and contribute to the use of multimedia learning resources, which have been shown to have positive effects on learning success (Herzig, 2014, p. 12). In particular, the combination of text and images or auditory and visual representations has been empirically confirmed to promote learning, as it reduces cognitive load and facilitates cognitive processing (cf. ibid., pp. 12–13). However, the question of the extent to which smartphones influence students' learning efficiency remains unanswered.

The ubiquitous spread of mobile devices among young people highlights their importance in everyday life. The results of the JIM Study 2023 underscore the widespread use of smartphones among school-age young people. Nearly all young people aged 12–19 own a smartphone (96%), while only 56% own a tablet (mpfs 2023, p. 5).

Figure 3

Device Ownership Among Young People in 2023 – Comparison With 2022



Source: JIM 2022, JIM 2023, figures in per cent, basis: all respondents, n = 1,200

Generation of Hypothesis

Empirical findings show that learners' initial motivation has a significant influence on their learning behaviour, learning performance and learning success (Stiensmeier-Pelster & Otterpohl, 2018, p. 569). The conceptual base for the integration of mobile devices into teaching is based on the work of Johnson (2019). Johnson suggests that the use of digital media in project-based teaching promotes increased interest, a greater focus on learning objectives and the application of deeper cognitive strategies (ibid., p. 98). According to Johnson (2019), deep learning strategies are characterised by the "elaboration of learning content". This phenomenon of deep cognitive strategies is primarily characterised by personal interest and manifests itself in connection with intrinsic motivation (Johnson, 2019, p. 87, Edelmann, 2003, p. 30). Students are very familiar with mobile devices from their everyday environment. Their use is associated with joy, pleasure and entertainment (Hirth et al., 2014, p. 139; Kleeberg-Niepage & Perzy, 2022, p. 426).

Schlicht's (2014) structural model for analysing learning success can be used to analyse the dimensions of learning success. This model considers learning success from the perspective of the pupils and understands learning as a multidimensional phenomenon comprising five essential elements: knowledge, abilities, skills, motivation and attitudes (Schlicht, 2014, p. 48). Knowledge, abilities and skills refer to "action plans relating to cognitive, sensorimotor, metacognitive and social processes" (Schlicht, 2014). Motivation, as a further element, encompasses emotional processes that relate to the will or intention to carry out an action. Studies show a correlation between student motivation and learning success (Stiensmeier-Pelster & Otterpohl, 2018, p. 569). The integration of digital media into teaching increases student motivation (Johnson, 2019, p. 87). It can therefore be assumed that the use of mobile devices for teaching purposes has a positive effect on learning success.

The fifth element, which encompasses students' attitudes, refers to long-term values that are both object- and situation-related and relate to their personal goals and motivations (Bilsky 2005, p. 301). These attitudes can influence how sustainable learning success is through the use of mobile devices. Students who are open to the use of digital learning tools may be more

willing to use these tools effectively and thus achieve better learning success in the long term. This leads to the following hypothesis.

H1: *Teaching with integrated mobile devices leads to greater learning success than teaching without mobile devices.*

The definition of a point in time during a lesson is based on the work of Goffman (1956, pp. 140–142; 1983, p. 16). He shows that a group of people who influence each other cognitively and socially adapts to temporal and spatial conditions and activities in order to achieve a given goal (Chian et al., 2021, p. 12). In the context of teaching, these points in time are called stages, phases or articulations (Grell & Grell, 1994, p. 104; Hoffmann et al., 2022, p. 78). Setting a point in time in a lesson is usually done using the phase model. A total of three phases form a scheme, and each phase has its own focus (Grell & Grell, 1994, p. 105, Krimmer et al., 2019, p. 49, Hoffmann et al., 2022, p. 76). It can be divided into three phases: introduction, development and consolidation (Meyer, 2017, p. 121).

The 15-minute model is used as a basis for defining the point in time at which mobile devices are used in order to achieve a balanced unit of beginning, middle and end (Hoffmann et al., 2022, p. 77). However, studies have shown that the three phases influence mental resources such as attention, motivation and efficiency (Baumeister & Vohs 2007, p. 126; Danziger et al., 2011, p. 1; Kleiner, 2011, p. 7). These study results have shown that, for example, in judgements, consumer behaviour and cognitive psychology, sequencing through phases has an influence on mental behaviour. It is therefore assumed that students' attention is strongest during the first 15-minute phase of the teaching process and then gradually decreases towards the end of the lesson (Schmid, 2022, pp. 165–168). This should make it possible to coordinate the actions of the students at specific points in time. The second hypothesis is based on this background.

H2: *Learning success at the start of the lesson is higher than learning success during the last 15 minutes of the lesson.*

In addition to their presumed potential to enhance learning success, smartphones also pose a risk of distraction. It has been demonstrated in young adults that the mere presence of a smartphone reduces attention and impairs cognitive performance (Beland & Murphy, 2016; Böttger et al., 2023; Skowronek et al., 2023). Al-Furaih and Al-Awidi describe the phenomenon of fear of missing out among students: “Fear of missing out describes the situation where a student cannot resist using their smartphone during lectures because of their desire not to miss anything that is happening, especially on social media” (Al-Furaih & Al-Awidi 2021, p. 2355). It is precisely those students who already have a low level of attention and little desire to learn who regularly look at their mobile phones. Mahsud et al. (2021) were also able to show that the prevailing culture of the country and the socio-demographic characteristics of individual students can significantly determine the level of attention.

The third hypothesis is that the risk of distraction from smartphones is lowest at the beginning of the lesson and that learning success is therefore highest at this point. This is justified by the fact that students had time to read and respond to their messages during the break. At the same time, it can be assumed that little new content has been uploaded to social platforms such as Instagram and TikTok that the pupils may have missed. The further the lesson progresses, the more the positive benefits of mobile devices for pupils evaporate due to the increasing potential for distraction.

H3: *The use of mobile devices within the first 15 minutes of the lesson is most successful.*

Methodology

A quasi-experimental framework is used for the study (Lehmann et al., 1998, p. 165). Variation is achieved on the one hand by distributing the work assignment with or without mobile devices, and on the other hand by choosing the time of output. This results in a 2 × 2 structure with four experimental groups (Aaker & Day, 1990, p. 317).

Table 1
Structure of the Experiment With Four Groups

		time condition	
		begin (< 0–15 min)	end (30–45 min)
mobile devices condition	yes (SP)		
	no (paper)		

Since there are numerous sources of interference and the schools may be highly autonomous, the design is based on repeated measurements (Lehmann et al., 1998, p. 152). This is also due to the fact that there are not enough homogeneous educational programmes at the six vocational schools studied to dispense with repeated measurements. There is no randomisation of the samples, and sources of interference are not controlled for by additional variables (Malhotra et al., 2013, p. 241). To ensure greater validity, the formal educational programmes of European Qualifications Framework (EQR) level four are selected at the vocational schools and the teaching material in the subject of economics is used (cf. European Qualifications Framework).

Depending on the assigned conditions, the classes receive a work assignment in paper form or for mobile devices. This creates a non-invasive way of collecting data that does not deviate too far from normal teaching. Therefore, the survey questionnaire also reflects the content focus of the lesson. Nine tasks are asked, divided into three levels of difficulty. These are based on the principle of arranging the transitions from simple to complex questions (Burns & Bush 1998, p. 303). The questionnaire was tested for comprehensibility and affordability in a pre-test (n = 14).

The paper-based assignment is adapted to the display area of a mobile device. If necessary, the assignment is printed on several sheets of paper, which are stapled together so that the worksheets cannot be placed side by side, thus preventing any advantage over the digital groups. The work assignment for processing on the device is provided as a PDF or via Forms. The tasks consist of solving closed (i.e. single or multiple choice, and cloze texts) and open tasks (i.e. text fields) based on an informational text or image. The larger proportion of closed questions serves to make data collection easier to code, in order to make the quantitative analysis more comparable and structured. This methodological approach helps to maintain the objectivity of the evaluation by minimising the problem of differences in interpretation and subjective influences in the analysis (cf. Lindner et al., 2018, pp. 241–242).

Worksheets and digital submissions are submitted or sent anonymously. Depending on the degree of difficulty of the task, the results are scored according to a fixed scheme in the form of a sample solution in order to measure the success of the work in the form of points. The study deliberately decided against collecting demographic data. This decision allows for a more targeted focus on direct influencing factors without being distracted by secondary variables. This focus increases the precision of the analysis and the overall efficiency of the study. There is no significant age difference between the groups studied.

Results of the Study

During the study period from March to June 2024, 16 classes were examined at six vocational colleges. Some of the classes (n = 4) were parallel classes, and some classes (n = 2) were tested twice. The total sample size was 243 students.

Evaluation Procedure

The points achieved were transferred to a data set (SPSS) for each task and added up as a total score (output). Missing and incorrect answers were coded separately. In 92 cases, the processing time was recorded. This reflects the measurement results of the four conditions of the study design: digital at the beginning of the lesson (n = 69) or at the end (n = 57), and paper at the beginning of the lesson (n = 57) and at the end (n = 60). The output achieved was tested for normal distribution using the Kolmogorov-Smirnov test ($D(243)$, $p > 0.05$). The distribution thus fulfils the condition of normal distribution, even though a histogram showed that the distribution is slightly skewed to the right. However, this does not pose a problem for the robustness of the unpaired t-tests (cf. Wilcox 2017, pp. 153–155). The output in the four experimental conditions was also normally distributed, with the exception of the group with devices at the end of the lesson, which is also skewed to the right. The application of the Winsorising procedure, in which the outliers are smoothed to the 5th and 95th percentiles, did not result in any improvement, so the outliers were not removed (Dixon, 1960, p. 388). The p-value was set at 5%.

Results for Hypothesis 1

Hypothesis 1 predicted a higher overall score in the group with mobile devices. A t-test with independent samples was performed for this purpose (Malhotra et al., 2013, p. 347). The two recoded groups show no significant deviation in the score ($t(241)$, $p = 0.29$). The mean values achieved for the devices ($M = 11.11$, $SD = 4.07$) and for paper ($M = 10.45$, $SD = 4.24$) were therefore not statistically influenced by this manipulation.

Table 2

Results for Hypothesis 1

	Levene's test of equality of variances		t-test for equality of means						95% confidence interval of the difference	
	F	Sig.	T	df	Sig. (1-tailed p)	Sig. (2-tailed p)	Mean difference	Std. error difference	Lower value	Upper value
Variances are equal	.965	.327	1.235	241	.109	.218	.65858	.53336	-.39206	1.70922
Variances are not equal			1.233	237.925	.109	.219	.65858	.53414	-.39367	1.71082

Follow-up tests on the group with mobile devices were then used to find other relationships. A t-test between the experimental groups of devices vs. paper with the independent variable of processing time (n = 97) shows that the groups with the devices submitted their answers 3.75 minutes earlier on average ((t95), p = 0.001). Cohen's effect size is large (d = 0.78). A cross-tabulation with a chi-square test was used to check the number of errors and empty answer fields (Mittag 2017, p. 101). The result shows that all groups made a similar number of errors overall (df(12), p = 0.76). However, it also shows that the device groups were more likely to leave more fields unanswered (df(9), p = 0.006).

Results for Hypothesis 2

Hypothesis 2 assumed that the time of entry into a group would result in a higher score than the time of securing results. An unpaired t-test was performed on the recoded groups (Malhotra et al., 2013, p. 347). There was no significant difference between the output of the conditions at the beginning (n = 126, M = 10.92) and at the end (n = 117, M = 10.64) (t(241), p = 0.59).

Table 3

Results for Hypothesis 2

	Levene's test of equality of variances		t-test for equality of means						95% confidence interval of the difference	
	F	Sig.	T	df	Sig. (1-tailed p)	Sig. (2-tailed p)	Mean deifference	Std. error difference	Lower value	Upper value
Variances are equal	4.376	.037	.530	241	.298	.596	.28358	.53473	-.76976	1.33692
Variances are not equal			.533	240.406	.297	.595	.28358	.53228	-.76494	1.33210

In further investigations of the relationships between them, significance could only be found for the difference between the two terminal device and paper groups at the end of the lesson (n = 57, M = 11.41 and n = 60, M = 9.90) (t(115), p = 0.034).

Results for Hypothesis 3

Hypothesis 3 focused on the most successful condition for output in the study design. It was assumed that the group using mobile devices at the beginning of the lesson would achieve the highest scores. An ANOVA test was used to test the four experimental conditions in relation to the independent variable of output (Mittag 2017, p. 270). The result is that the mean values are not significantly higher or lower in any of the groups ($F(3, 239) = 1.41$, $p = 0.24$).

Table 4
ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
between Groups	72.648	3	24.216	1.407	.241
within Groups	4112.813	239	17.208		
total	4185.460	242			

However, the standard deviation in the terminal device group appears to differ at the end (SD = 3.41 vs. SD = 4.56, SD = 4.25, SD = 4.20), and the Levens test shows unequal variance in the groups ($p = 0.014$). An additional Welch ANOVA shows no significance ($p = 0.24$), so that different mean values can be assumed (Moder 2010, p. 187). Due to greater robustness, an independent t-test was performed between the two groups (Wilcox, 2017, p. 155). The groups of mobile devices at the end of the lesson ($n = 57$, $M = 11.42$) and paper at the end ($n = 60$, $M = 9.9$) differ significantly from each other ($t(115)$, $p = 0.035$). However, the effect size according to Cohen is rather weak ($d = 0.4$). Further tests to find an effect between the parallel classes did not yield any significant results.

Conclusion, Limitations and Outlook

This study project involved conducting an empirical study to investigate whether digital media improves pupils' learning outcomes. Overall, the use of mobile devices did not lead to any improvement or deterioration. The use of mobile devices does not automatically lead to better learning outcomes. Rather, it is crucial how these technologies are integrated into the learning process (Breiter et al., 2013).

However, this highlights important starting points for the targeted use of digital media. It was found that students tend to hand in their work earlier when using digital devices and that more questions remain unanswered. Pupils who worked exclusively on paper, on the other hand, achieved lower scores on average, even only slightly. At the same time, digital groups seem to be less vulnerable to occasional break-ins, which could indicate greater flexibility in digital work.

A key point is that digital media should not be seen as a substitute for traditional teaching methods, but rather as a supplement to them. The greatest benefit is achieved when digital devices are used specifically to make lessons more interactive, individualised and flexible. However, it is necessary to focus exclusively on the educational goals and not on the technology itself. In addition to didactic integration, the technical infrastructure in schools is another essential prerequisite. Not only are mobile devices needed, but also stable networks and regular training for teachers. This will allow the potential of digital media to be fully exploited.

One limitation of this work is that all of the research groups studied are influenced by school autonomy. This is further exacerbated by differences between educational programmes. In addition, potential sources of interference that could also affect learning performance were not

taken into account. Furthermore, as the study does not address the differences in performance between classes, this may lead to distortions in the results. Another limitation concerns the spatial restriction. It should be noted that all data collected comes from schools in the greater area of Aachen and the surrounding region, which limits the transferability of the results to other regions. In addition, the methodology of the t-test should be considered a limiting factor. In a follow-up test to hypothesis 1, unequal group sizes (n = 24 vs. n = 73) were used to examine closer relationships at the time of submission. The group size of only 24 may influence the reliability of the statement made about the time of submission. Reference must also be made to the cross table, which was created as a follow-up to check the error frequency. Two of the 20 cells have three and four entries respectively, which is less than the usual minimum number of five.

The use of mobile devices did not show any significant effects on students' learning success in this study. This underscores the need for further research aimed in particular at eliminating disruptive factors and achieving more differentiated results. A criteria-based analysis could reveal the teaching situations in which the use of mobile devices makes the most sense. The question also arises as to whether students today can be better reached through the use of mobile devices than through traditional teaching methods.

An important point that should be considered for future studies is the classification of the results in relation to the previous performance level of the classes studied. It would be useful to analyse whether classes with higher or lower performance levels benefit differently from the use of mobile devices. This could help to develop targeted strategies for different target groups. The interaction between pupils' technical skills and the use of digital media could also be relevant for future research. For example, the extent to which technical skills or familiarity with the devices influence learning outcomes could be investigated.

In addition, it would be valuable to consider more individualised approaches, such as the use of mobile devices to support specific learning groups, e.g. lower-performing or particularly motivated students. An in-depth investigation of the emotional and motivational aspects of device use – as suggested in the study – could provide further valuable insights.

Finally, it would be important to look at the future of digitalisation in schools, for example by examining the impact of fully digital classrooms on learning success and teaching quality. At the same time, consideration should be given to how the technical infrastructure and regular training of teachers can be further developed in order to better exploit the potential of digital media.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

The author declares that no AI or AI-assisted technologies have been used to generate, refine, or correct the content in the manuscript. The ideas, design, procedures, findings, analyses, and discussion are originally written and derived from careful and systematic conduct of the research.

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